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Engineering Notes on Funchal, Madeira.

By J. P. H. PERRY.*

To the engineer visiting Funchal, the capital city of Madeira, the most interesting features are the transportation and paving methods, the types of building construction in use, and the bridges scattered through the town and its environs.

TRANSPORTATION METHODS. — Unique methods are employed in transporting people, merchandise and produce about the city. Instead of making use of wagons or carriages, wooden sleds drawn by oxen are employed. Wheeled vehicles are almost unknown. The sleds are built much like our own, the chief points of difference being the unshod runners and pivoted pole. Wooden runners are the rule; they are kept slippery by the drivers placing a piece of ham wrapped in burlap under first one and then the other runner. Owing to the extreme narrowness of the streets the pole is pivoted to permit an easy turning of sharp corners. When a particularly narrow place is reached the driver helps pull the sled about by means of iron handles or guides attached to the back of the sled. There is also much handling of goods by porters, who carry great weights on their shoulders with ease, as the view Fig. 2 suggests.

A GENERAL VIEW OF THE CITY OF FUNCHAL, MADEIRA.

For passenger conveyance sleighs with canopy topped bodies mounted on large springs are used. These *carro de bois*, as they are known locally, are decorated in fancy colors and are generally well upholstered. The private carros of wealthy citizens such as are used for going to the opera—there being a very large and well-supported opera house in Funchal—are draped in silk and are often elaborate. Considering the motive power the rate of speed of these carros is good. The native oxen, which according to United States standards are undersized, seem willing to travel at a trot and will respond quickly with a gallop when prodded with a sharp pole by the driver. There is little noise owing to the peculiar character of the pavements, and once the visitor gets over the novelty of sleighing without snow the comfort of the method of transportation is greater than might be supposed.

Before describing the paving it may be of interest to refer to the coasting or tobogganing. This if nothing else is characteristic of Funchal. A cog railway, which presents no special engineering interest, has been built from the center of the city to the Portuguese Cathedral, 2,000 ft. up the mountain side, where there is a hotel situated among beautiful tropical gardens and magnificent gorges. The return trip is made in wicker baskets mounted on wooden runners, to the front ends of which ropes are fastened. These sleds hold three persons. The incline back to the city is on grades of about 15 or 20%. The baskets slide over the cobble pavement fairly evenly and at increasing speed. Two natives, one on either side, have hold of the ropes, and by fast running keep up the toboggan; occasionally on long stretches of steep grade these men stand on the back ends of the runners to check the speed. When the speed becomes too great for safety or where angles in the road have to be turned these men hold the ropes. Where flat stretches are reached the guides run ahead of the basket sled and pull it along to the next slope. The trip is novel in the extreme, most interesting as a specimen of original methods adapted to local conditions. Fig. 3 shows some of these toboggans in action.

PAVING.—The pavements in Funchal are responsible for the success of the sleighing and coasting just described. The photographs Figs. 2 and 3 show their general characteristics. Small pieces of the hard rock of which Maderia is largely formed are laid on edge in a manner somewhat similar to our Belgian blocks. These blocks are usually about the size of a man's hand and vary in thickness from ¾-in. to 1½ ins. The foundation on which this top surface is laid is of two kinds. Ordinarily the ground is made hard and of an even surface by tamping and the blocks set on one edge in the dirt. Sometimes where an especially fine job is carried out a concrete base about 3 ins. thick is laid on the ground and the paving set in the concrete. In placing these blocks the practice seems to be to run them in lines across the street from curb to curb, each block touching its neighbor. The transverse lines of small blocks are separated by ¼-in. or ½-in. of dirt, and the blocks stick up out of the dirt about ¼-in. This gives a pavement with a fairly uniform surface and yet with means provided for the oxen to get a grip. The tops of the paving stones under constant use become smooth, and the frequent greasing of the sled runners as previously noted gives the upper edge of each thin piece of stone a slippery surface well adapted to the kind of traffic the pavement is designed for. These paving blocks seem to be found in the gorges and roadside cuttings, the native rock being a basalt which is laminated almost like a shale and breaks up into pieces of the size desired without much work.

For garden paths and sidewalks and poorer class roads through the country beach pebbles are used instead of rectangular blocks (Fig. 4). The shores of the Bay of Funchal are largely pebble beaches, and the proper sizes of round stones are easily obtained. In laying the garden walks in the Strangers' Club and in the beautiful surroundings of Reid's Palace Hotel these pebbles are arranged in elaborate patterns with attempts at times to select different colored stones.

BUILDINGS.—The houses in Funchal are almost wholly of stucco, English Portland cement being chiefly used. Cheap rough rubble walls tied together occasionally with light timber framing are first erected and then a thick stucco applied. The exact amount of stucco used depends upon the class of building. Generally about a 3-in. thickness is applied. In the treatment of the surfaces coloring is frequently re-

*Turner Construction Co., 11 Broadway, New York City.

sorted to, the favorite tints being blues, yellows and reds, and the corners of houses are sometimes built up of stone blocks laid with wide joints.

FIG. 2. PORTERS CARRYING FREIGHT FROM WAREHOUSE (FUNCHAL, MADEIRA).

The resulting structures are finished with red or brown semi-circular tile roofs. The appearance of the city can be judged by the accompanying cuts. There is rarely any frost and these plastered walls apparently stand the weather very well.

Some concrete buildings are to be seen in the newer sections of the town. The balconies of the Palace Hotel are of reinforced concrete. The columns, beams and slabs from superficial examination appear to have been designed according to current practice in this country. One or two concrete chimneys have been erected and several private residences with special treated concrete surfaces are to be found. The favorite finish seems to be roughcast panels bordered with light colored hard troweled surfaces. The tennis court of the Strangers' Club is also of concrete—a rather blistering surface at midday. Several concrete settees are scattered through the grounds of this club.

BRIDGES.—There are two fine masonry arch bridges spanning streams in the interior of the island. These mountain rivers are dry for long periods and then become torrents. The bridges shown in Figs. 6 to 8 are of recent erection. The spans run about 50 ft. each and the width of the structure is not over 18 ft. In some of the gorges older rubble masonry or concrete arches are found. These are said to be over 100 years old. Their most interesting feature is the scenic beauty of their situation, of which Fig. 5 shows a fine example.

The Practical Value of Chemical Standards for Iron Castings.*

By JOHN JERMAIN PORTER.†

In the final analysis, the test of a successful foundry is its ability to make money for its owners, and the three factors which determine its success are: (1) ability to make good castings; (2) the ability to make good castings cheaply; (3) ability to sell its product at fair prices. The composition of the metal going into the castings has a large influence on the first and second of these factors.

There are four factors on which the quality of a casting depends: (1) the chemical composition; (2) the treatment which the metal has received in melting; (3) the heat treatment, that is, casting temperature and rate of cooling; and (4) the perfection of the mold. These factors are probably of nearly equal importance and each is deserving of far more systematic and extended study than has yet been given it.

The cost of castings is not so greatly influenced by their composition and is perhaps chiefly a problem in the making of molds. In certain cases, however, it may play an important part, since the number of wasters or spoiled castings is often closely associated with the composition of the metal and there is nothing which will send the cost up so rapidly as a large percentage of bad castings.

The cost is also influenced by the chemical composition of the metal in another way. That is, by the cost of the iron used. This comes about from the fact that for any given casting there will be several different compositions, or perhaps a wide range in composition, any one of which is equally good. Some one of these, however, will be cheaper than the rest and hence the foundryman who works according to analysis and with full knowledge of his requirements in the way of composition can effect a saving in cost, which, though small, is not unimportant.

As an example of this, I would mention the case of the ordinary run of machine tool castings which are so commonly made in the foundries of this district. These castings are of medium thickness and must be soft enough to machine. Owing to the fact that the foundry is not commonly considered to have any rights that the machine shop is bound to respect, our foundry superintendents have had it most firmly impressed upon them that no crime is so heinous as that of turning out hard castings, and hence the custom has grown up of using from 0.25 to 0.50% more silicon in these castings than is necessary, in order to insure immunity from machine shop kicks. In other words, 2.25% to 2.50% silicon is very frequently used in work where 2% is quite sufficient. Now, if we examine the market reports of the price of pig iron, we find that there is an average difference of 50 cts. per grade number per ton of pig iron; that is, if No. 2 sells for $14.75, No. 1 will sell for $15.25. It is also a fact that the grade numbers represent a variation of 50% of silicon; that is, No. 2 averages 2.25% and No. 1, 2.75%. Thus it may be said that each 0.01% silicon costs 1 ct., and if we use 0.25% more silicon than is necessary in our m[illegible] increase the cost of our metal just [illegible]

This may seem like a small thing [illegible] only 1-80-ct. per lb. to the cost o[illegible] when we consider that the excessiv[illegible] used has a very injurious effect [illegible] ducing dirty iron and porous places i[illegible] and thus is sometimes accountable [illegible] number of spoiled castings, the p[illegible] so trivial.

Another case is found in the ex[illegible] use of manganese by some of our best informed [illegible] gers who have learned to appreciate its excellent ef[illegible] giving clean, sound iron, and in reducing the ser[illegible]. One of my foundry friends tells me that by th[illegible] of high manganese pig iron he is enabled to u[illegible] amounts of very cheap high sulphur pig, the m[illegible] e counteracting the injurious effects of the sulphur [illegible] being itself comparatively inexpensive. He says [illegible] that he has not had a ton of No. 2 iron on his yard for months, his requirements being obtained by mixing a cheap high silicon high sulphur iron with other cheap low silicon high manganese irons. Of course with this procedure, very close attention to the details of charging and the methods of receiving the iron in ladles is necessary, but the fact that it can be and is done successfully is worthy of careful attention by our members.

This naturally brings us to the reason why our knowledge of foundry metallurgy is not more generally used. The answer to this question, may be found in the fact that the various data have not been got together in such form that the practical foundrymen can readily use them. It is well known that within recent years, especially, vast additions have been made to our store of information regarding cast iron, but two facts militate against the use of most of it. The first of these is that but little of this material has been gathered together in handbooks or in such form as to be readily available for use. Most of it, and that the most valuable part, has been published in the various technical journals, and the foundryman who wishes to find the best kind of iron for making hydraulic cylinders, for example, would have to search through the files of perhaps a half dozen journals, and it might take him two or three days to dig out all the information available on the subject. The other factor is that so much of the material published is written up from the scientific point of view rather than the practical, and hence is not in a form to be understood and applied by the foundryman.

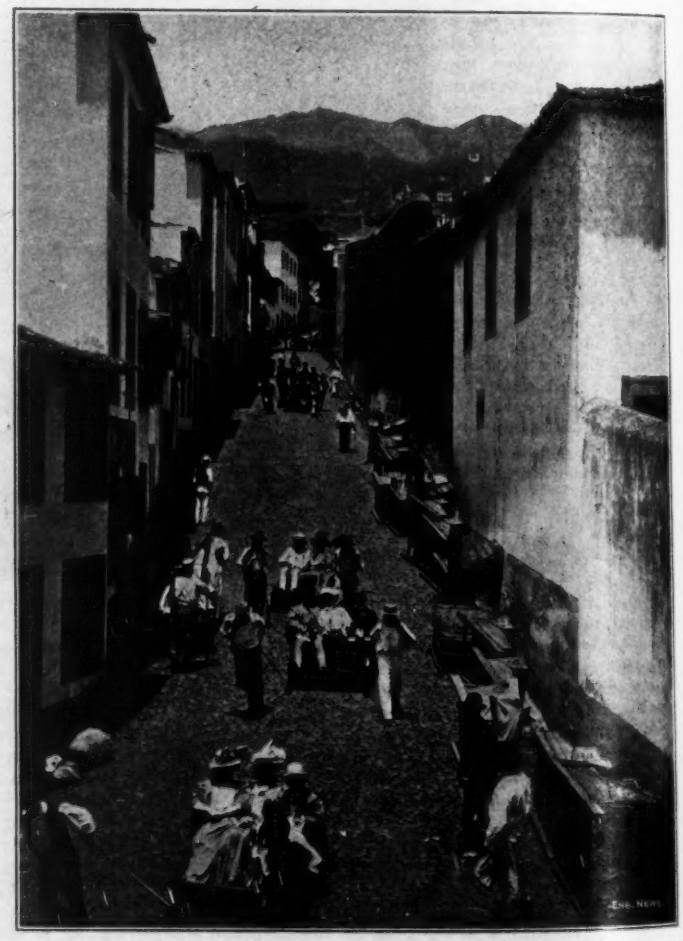


FIG. 3. COASTING DOWN HILL FROM THE CATHEDRAL.

It is true that this scientific work is of the highest importance, indirectly, but it needs to be thoroughly digested, correlated with practical experience and the re-

*From a paper presented at the annual meeting of the American Foundrymen's Association, held at Cincinnati, Ohio, May 18 to 20, 1909.

†University of Cincinnati, Cincinnati, Ohio.

sults rested in ordinary foundry language in order to make it available for practical use. There has also been done an enormous amount of technical experimental work which fails to be of value because of incompleteness, for example, data connecting the strength of iron with varying percentage of silicon are meaningless unless the percentage of other elements are also given. Moreover, statements that an iron of a given composition has such and such a strength is of very little use taken by itself, since the value of a casting is seldom dependent upon strength alone and there are many other properties of cast iron, such as hardness, shrinkage, density, etc., which must also be considered.

Looking at it from this standpoint, it will be seen that the problem is very complex and not to be approached lightly. Some 20 different physical properties of cast iron may be enumerated which influence its value and adaptability for the manifold purposes for which castings are used. Cast iron may be regarded as an alloy of six elements: iron, carbon, silicon, sulphur, phosphorus and manganese, and since these elements may be combined in various ways, we may have some 12 or 15 different constituents. Since each separate constituent has or may have a specific effect on each of the 20 physical properties, it will be readily seen that if the problem is to be investigated systematically from start to finish an almost infinite amount of work will be required.

As a matter of fact, such an accumulation of data would, after all, give us only half the information we require, since in a great many, perhaps the majority of cases, the exact physical properties which are necessary to make the best casting of any particular class are not well defined. For example, to take the case of a foundryman making hydraulic cylinders, even supposing that he had all this data at his command, it could not aid him unless he knew also, exactly what degrees of hardness, strength, density, etc., are most desirable in his cylinder.

Evidently, then, the most feasible way of placing this metallurgical data before the foundryman in such form as to make it of practical value, is to first classify castings according to the physical properties which are of importance in them, and then to tabulate the chemical compositions which are found suitable for each class. It would also be highly desirable to take some cognizance of the factor of the cost of the mixture and show, where possible, how the foundryman could cut down the cost of his iron without decreasing the quality of his product.

An investigation carried out along these lines, while involving considerable work, would not be impossible and would certainly be of immediate and direct benefit to the foundry industry. The data needed could be obtained very largely from material already published and from inquiry among plants making the various lines of castings. Some experimental work would undoubtedly be needed to fill in the gaps, but I do not believe that it would be very great in amount.

With regard to the classification of castings, Thomas D. West has outlined a system of classification and divided castings into 34 classes.*

*"Suggestions for Procedure in Formulating Standards for General Castings." Trans. Amer. Society Testing Materials, 1903.

FIG. 4. A PARK WALK OF PEBBLES.

A Duplex High-Pressure Fire Protection System for a Portion of New York City.

In an extension to the high-pressure fire system on the lower east side of Manhattan Island, New York City, bids for which will be opened on June 9, 1909, a novel feature has been introduced for the purpose of guarding against interruptions in the service through breaks in the mains. We give below a general outline of this system, supplied us through the courtesy of Mr. I. M. de Varona, Chief Engineer of the Department of Water Supply, Gas and Electricity of New York City.

The extension in question will include some 33 miles of 24 to 6-in. cast-iron flanged and bolted mains, with necessary gates and hydrants. About half the mileage will be of 12-in. pipe. The extension will lie in a district bounded by Houston St., the Bowery, James St., and East River. The high-pressure pipes will be supplied from a pumping station at or near James Slip. The description of the duplex feature of the system, with an explanation of its object, follows:

In all the high-pressure fire systems hitherto designed, the weak point, and a vital one, is the danger of total interruption of the service in case of a break in the mains. It takes, say, from five to ten minutes to locate a break, and even under the most favorable conditions it hardly can be reached, after it is located, in less than five or ten minutes; while the time required after arrival to shut down by hand the two, three or four valves which have to be operated to isolate the broken section, may range from 20 to 30 minutes. During all this time the entire system remains out of service.

On Dec. 16, 1908, during a fire at Grand and Mulberry Sts., a break occurred on the 20-in. main in Center and Broome Sts., in an excavation made by the contractors constructing the Center St. subway, which put the entire high-pressure system out of service until the break had been located and isolated. The Brooklyn high-pressure system was subjected to a similar experience, although not during a fire, when a gas explosion in an excavation for sewer construction on Gold St., tore away and made useless a portion of the high-pressure main on that street, also putting that entire system out of service until the proper gates were shut to isolate the section affected thereby.

Excavations similar to those above mentioned are constantly being made in the streets occupied by the mains of the present system, and even with thorough inspection it is a practical impossibility to absolutely safeguard it against the carelessness of contractors or their errors of judgment in supporting and protecting either the mains exposed or those lying close to the excavations made by them.

The Department of Water Supply has been at work devising some means to minimize the difficulty by so subdividing the general distribution system that shut-offs of sections in which a break occurs may be more quickly made—utilizing also for that purpose the indications of fall in pressure at the pumping stations when a break occurs—and hopes for favorable results from the plans in preparation.

Those made for the extension of the high-pressure fire system are the result of studies made to remedy the inherent weakness of the systems so far designed; and what may be designated as a "duplex" system was adopted, as that most effectually guarding against the consequences of a sudden break without affecting the loss of pressure or cost of installation to any considerable degree.

The "duplex" system consists in reality of two

FIG. 5. A GORGE VISTA IN MADEIRA.

interlaced but independent systems which connect only at three points, the connections being controlled by valves electrically operated from the pumping station.

A break on either system will immediately show itself on the Venturi chart or pressure gages on the pumping-station outlet to that system and the simultaneous closing of the three valves referred to will entirely isolate the crippled system in about one minute, and the other system will still continue in operation.

The mains of the two systems occupy alternate streets and, therefore, with system "A" shut down, the hydrants of system "B," the greatest distance to the nearest of which from any point in the area covered by the extension does not exceed 500 ft., will remain in service and can be relied upon to furnish protection against fire until the break on system "A" has been located and the necessary shut-offs made to again bring that system into service. Either system will be sufficient to control ordinary fires, but normally both will be jointly brought into service at the start of a fire.

The large saving in time in shutting down the affected system, and the ability, in case of a break, to keep in service unaffected hydrants sufficiently near to any point to be of service, are deemed an important improvement, considerably increasing the efficiency of the system in protecting against fire the area covered by the extension.

The Future Development of Machine Molding.*

By GEO. MUNTZ.†

We have passed from the plain squeezer performing only the ramming of the sand, to the most complicated automatic machines, which take a flask from a laborer's hand and return a mold. The molding machine has taken the place of the molder in certain cases, but not in all cases because it lacks adaptability. A bench molder able to handle a range of flasks from 10 × 12 ins. to 16 × 20 ins., will be able to mold anything that can be put in those flasks, no matter how flat or deep the castings may be. That is what we call the adaptability of the molder.

The present automatic molding machines do only such work as they have been designed for. The field seems then to be a small one, as for each class of work a special class of machine is required. I believe that a machine, just as adaptable as the molder, can be built.

To make a mold, a machine has to be given all that is given to the molder: a pattern, a flask, and sand. Then it must be provided with mechanical contrivances which will enable it to ram the sand, turn the mold over and draw the pattern. That is all that the molder does while molding. The patching up of the mold seems to be the only part requiring great skill from the molder. This could be done away with if the patterns were perfect, and if the molder were drawing them perfectly vertical when taking them out of the sand. It is there that the molding machine shows its superiority over the man, because if it is built to draw the pattern vertically, it will do so and do it all the time.

The main drawback to a universal molding machine is the lack of a universal ramming device. As far as the ramming is concerned, the molder is universal. He knows that if he molds stove castings, he will have to ram the sand a certain way; if he molds hollow ware, he will have to ram the sand another way. In some molds the sand has to be rammed differently during the progress of molding, and this the molder can do.

The ramming question has been tackled in different ways. The rammer of the molder, when it comes down on the sand, squeezes it upon a certain area, and it had been thought that if the rammer were enlarged so as to cover the entire flask, and sufficient pressure applied, the ramming could be done just as well. It was the origin of the squeezers.

Practice shows that the piston or squeezer plate does not act like the rammer, and this on account of the physical condition of the sand. If sand were absolutely dry and free of clay it would pack perfectly even. But foundry sand needs a binder and needs moisture, and therefore becomes the poorest thing in the world to be compressed evenly over uneven surfaces.

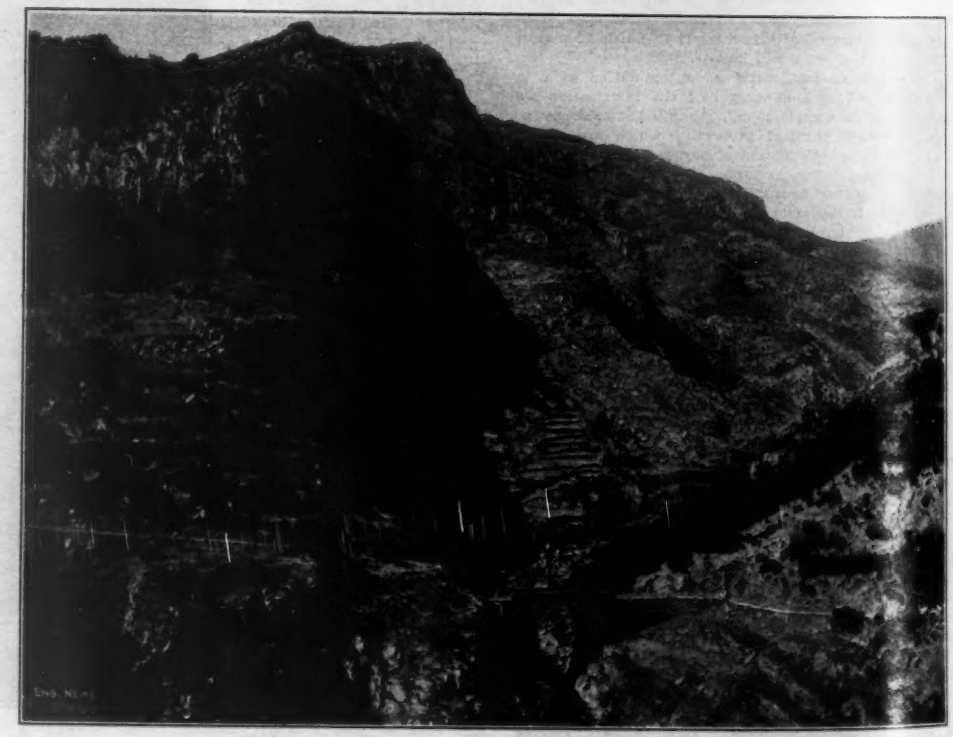
While the ramming is uneven in the immediate neighborhood of the pattern, it becomes very uniform above a certain distance of the pattern. This observation brought Ph. Bonvillain and E. Ronceray to build their disappearing pattern molding machine. This machine is a squeezer, but the sand which is packed evenly over the pattern, is in turn used as a piston to compress the lower layers of sand. This is done by building between the pattern and the piston supporting it, a prismoid following exactly the outline of the parting line of the pattern, and having about one-third of the pattern height. The whole slides through a stripping plate and when only the portion of the pattern which is wanted appears above the stripping plate the ramming stops, while the pattern still goes down, drawing itself through the stripping plate.

This method has been successfully applied and I have seen six 8-in. projectile shells, about 12 ins. long molded in a 14-in. round flask, leaving ¾-in. sand walls, and the sand was perfectly packed. The only apparent drawback is the cost of the pattern plates and the enormous machine required for a comparatively small flask.

Another French inventor recently had the idea of using compressed air, but without any piston. The flasks he uses are special and when filled with sand, are covered with a chamber the bottom of which is a rubber sheet. Compressed air is then admitted, and the rubber sheet acts as a piston and squeezes the sand evenly. Of course, the surface of sand left by the rubber sheet, is far from being a plane, and requires some striking off for each mold.

In ornamental molding and in deep [illegible]rk, the molder often takes the sand in his hand in [illegible]hape of a soft ball, and throws it on the pattern. [illegible]is operation is repeated a certain number of times, [illegible]whole mold can be rammed in this fashion. This o[illegible]ation was the origin of the so-called "gravity ma[illegible]s." It is evident that in such machines, the mold [illegible] to be guided by hand, or else the sand would be pack[illegible] harder in some places than in others. This introd[illegible] the personal equation of the man, which is the [illegible]est antagonist to automaticity.

There is another method, used [illegible] by the core maker than by the molder, and whic[illegible]sists in taking a corebox full of sand and pounding [illegible] a table until the required degree of hardness of t[illegible]d is attained. This method has been very successf[illegible]pplied in the "jarring machines," and molds are m[illegible] this method that are perfect in every respect. T[illegible]ly inconvenience I experienced with such machi[illegible] was that the sand would not pack hard enough on [illegible] of the mold. This was easily remedied by casting h[illegible] plates of the size of the flasks used and placing th[illegible] on top of the molds while ramming.



FIGS. 6-8. THREE MASONRY ARCH

*Abstract of a paper read at the annual convention of the American Foundrymen's Association at Cincinnati, O., May 18 to 21, 1909.

†West New Brighton, N. Y.

Of course the jarring machine requires heavier foundations than any of the other molding machines, but such foundations are made every day for steam hammers, and I fail to see why the same sacrifices should not be made in the foundry.

It always seemed to me that molding machines were considered like step-sisters to the other machine tools, and that every effort was made to keep them from attaining the same degree of perfection as the modern lathes and milling machines. To do away with skilled labor, very intricate machine tools have been built, and every operation of the machine has been designed to replace some motion of a skilled hand. It is in this manner that a screw machine fed with a roll wire turns out thousands of perfect screws under the mere supervision of a boy or an unskilled laborer.

When the molding machine salesman interviews the purchasing agent of a foundry, he is always received by the latter with a desire for a very simple machine, which will do in the hands of an unskilled man the work of a skillful molder. Molding machine manufacturers have then, thus far, only been able to produce fractions of the machines which would do, in the foundry, what the automatic lathe and the copying milling machine do in the machine shop. A molding machine to be as universal in the foundry as the automatic lathe is universal in the machine shop, has to be just as complicated and what is more, has to be built so as to meet the exacting condition created by the presence of dust and soot.

The molding machine of the future will be as automatic as the improved machine tools of the machine shop. It will be belt driven, or be self contained and have its own electric motor. It will unquestionably have a universal ramming device based on the jarring method of ramming, an automatic clamping device, which will allow the molds to be rolled over without any fear of the flasks coming apart from the pattern plates, and an automatic and adjustable pattern drawing arrangement.

The foundrymen say that it will take mechanics to run such machines. It will not do so, any more than it takes mechanics to run automatic screw machines. In every machine shop there is a tool maker who has the supervision of all the machines and equips them with the tools without which they would not be automatic. In the modern foundry there will also be a kind of tool maker, but besides being a machinist he will have to be a molder. He will make the pattern plates and look to the fulfillment of good working conditions of the machines.

Best Method of Staying the Front Portion of Crown Sheet (in Radial-Stay Boilers) to Prevent Cracking of the Tube Sheet.*

In the smaller and medium size radial-stayed locomotive boilers, with tube sheets from 34 to 38 ins. wide, and having from 135 to 160 tubes, which remain comparatively tight, cracks do not develop for from 5 to 7 years. In the wide firebox type of boiler, designed for from 180 to 210 lbs. maximum pressure, containing from 300 to 400 flues, which leak almost daily, the tube sheet will crack in from 1½ to 3 years.

When tubes are reset, considerable tension is put on the tube sheet, the sheet sometimes stretching from $^{3}/_{32}$-in. to $^{5}/_{16}$-in. When heat is applied, the part in tension naturally moves toward the point of least resistance, i. e., the top of sheet. The almost daily working of the tubes, whether with sectional expander, roller, caulking tool or pin, tends to accelerate the movement. As a larger number of tubes are worked along the vertical center of tube sheet than along the sides, it follows that the stretching of the sheet is greatest through the center. The continued expansion results in a cracked margin, near the center of upper flange, starting at a tube hole and often continuing through the roof of flange into a rivet hole. The narrower the margin above the tubes, the greater will be the tendency to crack. All other conditions being equal, the deterioration of a tube sheet in a bad-water district, where tube leakage is considerable, begins much earlier than in a good water district where leaky tubes are the exception. The life of the former will be from 3 to 5 years, of the latter from 6 to 8 years.

The style of bracing at the front portion of the crown sheet does not seem to add to or detract from the integrity of the tube sheet, or its ability to withstand successfully the strains put upon it. There are three styles of bracing of about equal value, so far as the tube sheet is concerned: crown bars, eye-bolts and tee-bars, with sling stays attached. The two latter are more generally used.

On one of the large railway systems over 100 large size switch engines having radial-stayed boilers, with two rows of sling stays next to tube sheet, have been in service from 1 to 17 years. The sheets in these engines are in good condition, with an almost perfect flange, due to the fact that the tubes seldom leak, and therefore the sheets have not been stretched by working the tubes. No tube sheets have been renewed in these engines up to date.

On this system are a large number of radial-stayed boilers, a part of which have eye-bolts and sling stays across the front end of crown sheet, the balance have the tee bar style of bracing. Under favorable conditions the tube sheets in these engines last from 5 to 15 years. Where opposite conditions exist, they last from 3 to 5 years, the top flange being bent down from 1 in. to 1¼ ins., and the sheet being cracked from a number of the top tube holes to rivet holes.

Regarding the methods employed for the prevention of flue sheets cracking, the following is pertinent. On a number of railways the sling-stay style of bracing, with an eye bolt in both crown and roof sheets, and the tee-bar arrangement have given satisfactory results. The tee-bar bracing is to be preferred as it is the more substantial. A serious drawback to the eye-bolt arrangement is the fact that the eye-bolts occasionally break, are sometimes not readily detected, and are inconvenient to remove, especially when the broken stay is located back of the front row. It is then necessary to remove the brace or braces ahead of it. Another advantage of the tee-bar is, that fewer braces are necessary, giving the front of firebox greater freedom of movements.

The bolts of these braces should be $^{1}/_{32}$-in. greater in length, from head to shoulder, than the combined thickness of braces and web of tee-bar, to allow braces to move freely. Care must be taken in applying braces, to insure sufficient space for expansion between either end of brace and leaf of tee-bars. It is usual to slot the holes in the braces from ¼-in. to ⅜-in. at the top end, or half this amount at either end. In bad water districts, it is preferable to slot the upper holes only, on account of the liability of lower ones filling with scale, causing the braces, in time, to become immovable.

In applying the eye-bolt arrangement of sling stays, the eye-bolts for crown sheet where a button-head bolt is preferred, are made with an enlarged neck or shank, the button-head bolts may be tapped into them. Where a smaller head is required, the eye-bolts may be tapped into the crown and hammered over. The eye-bolts in roof sheet are either hammered over or fitted with nuts, a copper gasket being placed under the nut. When flat braces are used, it is customary to slot the hole in upper eye-bolt. With the double-jawed brace with forged eye slotting is unnecessary, as the oval-shaped holes furnish ample room for expansion.

Regarding the number of sling stays, no standard is followed; from two to five rows are used. The same is true of tee-bars, some roads using one, and others two.

For further prevention of cracks, we would recommend that no unnecessary work be done on flues, as it tends to destroy not only the tubes, but also the tube sheet, also that the upper tube holes be located not less than 4 ins. from center of hole to inside of flange, leaving out 8 or 10 of the top flue holes. The front tube sheet pockets to be put in the second row from top where possible, beading the front end of the top row of flues to brace the front sheet.

*Abstract of a committee report presented at the annual meeting of the International Master Boiler Makers' Association, at Louisville, Ky., in April, 1909.

BRIDGES IN MADEIRA, NEAR FUNCHAL.

New Schedule of Post-Graduate Training for Army Engineers.

Everybody knows that the officers of the Engineer Corps of the army are taken from among those West Point graduates who stand highest in their class. A high-grade material is thus secured for the Corps. These graduates are put through a course of apprenticeship in practical work, under older Engineer Corps officers, to fit them for directing and planning independently.

This course of training has recently been crystallized in definite form, in the shape of an order issued by the Chief of Engineers which specifies the time and nature of the apprenticeship. The plan laid down thereby is to go into effect at once, that is, it will apply to the West Point class graduated next month.

The new course of training is described as follows:

Graduates assigned to the Corps of Engineers will be ordered on the expiration of their graduation leave to report for instruction to Engineer officers in charge of selected Engineer districts, where they will have an opportunity to study the theory and practice of engineering as applied to various important construction works of the Corps. This assignment will be so arranged that each young officer, during his first year of service, will have experience on the Panama Canal, on breakwater or jetty work in connection with harbor improvements, on river improvement including canalization and movable-dam construction, and on rock excavation under water, dredging and similar work. During this period these officers will be required by the district engineer officers to make a thorough study of the works in progress, and to take notes on what they see and do. The last two weeks at each station will be devoted to writing a descriptive memoir upon the works observed, which shall include a comparison of the theory and practice of the work under observation. This memoir will be sent through the immediate commanding officer, who will indorse thereon such remarks as may be pertinent, to the Chief Engineers, for submission to the Engineer School. If the memoirs are satisfactory to the School Board the author will be given a corresponding credit in the school course.

The second year after graduation will be spent at the Engineer School at Washington Barracks, where the student officer will take the prescribed course in civil engineering, light-house construction, mechanical and electrical engineering, seacoast defenses and permanent fortifications, including land defenses of important harbors. This course will embrace such theoretical and practical instruction as is necessary to fit the officers for their duties as constructing engineers on the works under the charge of the Corps.

Upon the completion of the course at Washington Barracks, the young officers will be assigned to civil or military duty for several years as assistants to older officers. Assignments will be so arranged that each officer will serve with Engineer troops for at least four years before attaining the rank of captain. At least one

year of this period will be spent at Fort Leavenworth, Kan., where the student officers will be separated from direct service with Engineer troops and will take the course at the Engineer School of the Line. During this period of instruction the junior officers will be brought into immediate contact with other troops of the line in order that they may be fully fitted to perform the duties of Engineer officers with the mobile army.

The Order then gives a short list of books and Engineer Corps publications which should be read during the apprenticeship. They comprise such works as books on river and harbor work, official papers on rivers, Merriman's "Hydraulics," Major Starling's paper on Mississippi Floods, which appeared in Engineering News a dozen years ago and has since been reprinted, etc.

Waterbury Sewage and Its Septic Action.

By WM. GAVIN TAYLOR,* M. Am. Soc. C. E.

For a period of eighteen months, beginning in June, 1905, a comprehensive study was made of the detailed characteristics of Waterbury sewage, its behavior under septic and other preliminary treatment, and its purification in contact beds, sand and percolating filters. The results of these tests have never been published. Although two years have elapsed since the completion of the tests, yet it is believed that the features outlined in this paper will prove of value and interest.

A general statement of the fixed conditions, showing why the tests were required in the local study, together with a brief description of the testing station, were published in Engineering News for Feb. 28, 1907. The present paper sets forth the characteristics of Waterbury sewage, together with its peculiar action under septic treatment.

In general the sewers in the principal drainage districts of Waterbury were designed for and have been used upon the combined system. During the past few years, however, many storm-water sewers have been constructed with the idea of ultimately completing dual systems.

The larger trunk sewers are of brick, while the smaller, together with the tributary lines, are of vitrified pipe. Owing to the steep gradient of the valley of the Naugatuck River and the bold topography of the bounding and tributary hillsides, many of the sewers are laid to very steep grades and consequently the velocities attained within the sewers are often great. Resulting from these geological conditions, in conjunction with the particular sewage, many interesting characteristics exist which will be shown later in connection with the freshness of the sewage content at the time of its discharge into the river, the hourly variation in the sewage flow and chlorine value and the bacterial life in the sewage.

The quantity of sewage now intercepted by the main carrier, a reinforced-concrete sewer leading to the proposed site of the purification works (Eng. News, March 26, 1908), averages 10,000,000 gals. daily. The ratio of the hourly sewage flow to the daily mean varies with great rapidity, owing to the high velocities in the tributary mains and the topographical features, the variation in hourly flow being graphically shown in Fig. 3.

Besides the large volume of surface water reaching the sewers through street inlets and rain-water roof-connections during storm conditions, a considerable quantity enters by infiltration through uncemented inlet hubs, effecting a marked dilution of the sewage. Increase in the sewage flow from this latter source is particularly noticeable for several days after heavy rainfalls. The dilution is still further increased by the high average consumption of potable water—139 gals. per consumer.

The first effect of the entrance of storm water upon the character of the sewage is to greatly increase the amount of total and fixed suspended solids, due to the flushing of the pavements and the washing into the sewers of much road detritus. The carbonaceous matter, as shown by the oxygen consumed, is materially increased, as are also the nitrogenous compounds. After this first flushing, however, the sewage is weakened by dilution.

During the year of tests covered by this paper, November, 1905, to November, 1906, the sewage was continuously pumped and treated, except upon two days during which alterations were being made. The sewage for the tests was drawn from the mid-depth of the stream in the sewer and discharged into a small screen chamber. Within this chamber the sewage passed through a galvanized-iron wire screen having ½-in. meshes. The coarse material caught by this screen amounted to 140 lbs. or .08 cu. yd. per 1,000,000 gals. of sewage pumped. The material intercepted was largely kitchen wastes and coarse fecal and cellulose matters. A daily cleaning of the screen was generally sufficient.

A standard arrangement was adopted at the inception of the tests, by which the samples of the crude sewage, the influents and effluents of the preparatory devices and all of the filters were systematically collected and prepared for detailed chemical and bacteriological analysis. The samples were collected during seven consecutive days and skipped on the eighth day. This arrangement made it possible to have definite rest days and yet each day of the week

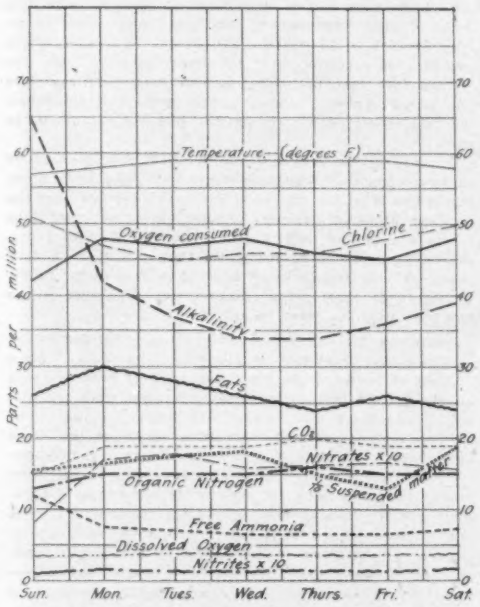


Fig. 1. Average Daily Variations.

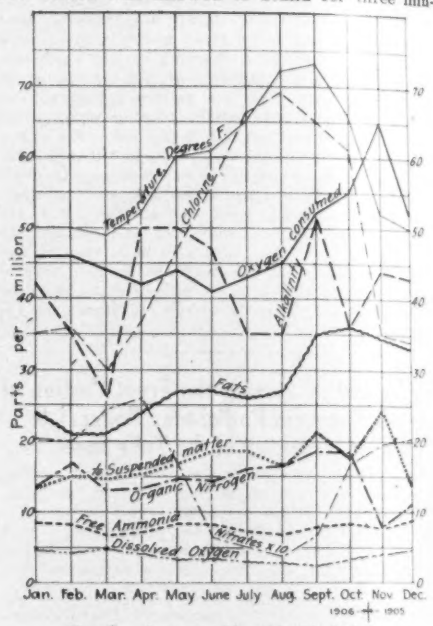


Fig. 2. Average Monthly Variations.

FIGS. 1 AND 2. VARIATIONS IN THE CONSTITUENTS OF THE SEWAGE OF WATERBURY, CONN., NOVEMBER, 1905, TO NOVEMBER, 1906.

would have its proper weight and proportional value in the monthly and yearly averages. The crude-sewage samples were drawn within the laboratory, from a pipe connecting into the screen chamber just beyond the roughing screen, but neither grit nor other matter had been removed by subsidence. A 4-oz. bottle was completely filled with the crude sewage each half hour, tightly corked, and immediately placed in a refrigerator having a temperature less than 50° F. Upon the collection of the last half-hour sample in a daily series, the 4-oz. portions, 48 in all, were aggregated into a single composite sample, which was immediately subjected to detailed chemical analysis, and the results weighted to balance the hourly fluctuation in sewage flow.

Throughout the work the general methods used in the different determinations have been those adopted by the American Public Health Association and commonly known as the "Standard Methods," although in some particulars modifications were made as stated beyond.

In the determination of organic nitrogen the method resulting from investigations of Phelps* and of Kimberly and Roberts† upon direct nesslerization was slightly modified and adopted in place of the distilling method of Kjeldahl. To prove that the direct method w[illegible] applicable to the local conditions and that the [illegible]lts obtained by the two methods were in a[illegible], 75 duplicate samples of crude sewage, s[illegible] tank, sand and sprinkling filter effluents [illegible] taken and comparative analyses were mad[illegible] with the result that the average of all th[illegible]erminations was the same for each method, [illegible]ough the individual results varied slightly [illegible]ay or the other. The tests covered many [illegible]s and conditions through the different se[illegible], and they proved that the quicker and [illegible] convenient method of direct nesslerization [illegible]d be used throughout the local tests with th[illegible]urance that comparable results would be ob[illegible]d.

Free ammonia determinations [illegible] also made by direct nesslerization and the [illegible]ts were in substantial accord with those obt[illegible]ed by distillation.

Oxygen consumed, as an approxi[illegible]e measure of the organic carbon in the sewage, was determined by adding an excess of [illegible]ssium permanganate to the acidified sewage sample when cold, and allowing a five minutes' digestion after reaching the boiling point. Parallel with this method a large number of determinations were made upon duplicate samples, in which the portion tested was allowed to stand for three minutes in contact with a cold acid solution of permanganate. In general the average amount of permanganate found to be decomposed was to that shown by the five-minute boiling test, as 1 is to 5.

Suspended solids in a sewage are of particular value in a purification study and they have in the present case been regularly determined by the Gooch crucible in accordance with the method recommended by Kimberly & Hommon.* The Gooch-crucible method offered many advantages over the platinum method in quantitative results, in quickness of operation and in the general amount of work that could be carried along at one time. For comparison of methods, however, parallel determinations were run during five months—February to June inclusive. The work done upon total solids was sufficiently comprehensive to be of much value and adequate to show the ratio existing between the suspended matter values as determined by the two methods. In the Waterbury sewage it has been found that the total suspended and total suspended volatile matter by the platinum method was respectively 89 and 74% of that obtained by the Gooch-crucible method.

The composition of Waterbury sewage, as shown by averaging the chemical analyses of 314

*Resident Engineer, Sewage Disposal Works, Waterbury, Conn.

*Phelps Jour. of Infectious Diseases, Supple. 1, May, 1905.

†Kimberly & Roberts, Jour. of Infectious Diseases, Supple. 2, Feb., 1906.

*Kimberly & Hommon, Jour. of Infectious Diseases, Supple. 2, Feb., 1906.

daily composite samples, consisting of 15,072 half-hourly portions, is shown in Table I.

TABLE I.—AVERAGE CHEMICAL COMPOSITION OF WATERBURY SEWAGE, NOV., 1905, TO NOV., 1906.

(Parts per million.)	
Temperature, degrees F.	58
Oxygen consumed, total	46
Oxygen consumed, dissolved	26
Oxygen consumed, suspended	20
Organic nitrogen, total	14.8
Organic nitrogen, dissolved	10.3
Organic nitrogen, suspended	4.5
Free ammonia	7.8
Nitrites	0.14
Nitrates	1.52
Chlorine	48
Suspended matter, total	165
Suspended matter, volatile	115
Suspended matter, fixed	50
Dissolved oxygen	3.8
Free CO_2	18
Alkalinity as Ca CO_3	41
Fats (ether soluble matter)	26

The sampling schedule gave each day of the week an equal weight in the general yearly average. The results of the daily analyses have been arranged, averaged and plotted in the form of a diagram, Fig. 1, to show the week-day variations in the composition of the sewage.

The nitrogenous compounds, dissolved oxygen, free carbonic acid, and suspended matter varied but little from day to day, except that the free ammonia number was universally higher on Sunday, owing, doubtless, to the lessened sewage flow, the reduced velocity in the sewers and the consequent increased time of travel to the outfall. The fats were markedly higher on Monday by reason of the general use of soap on that day. The alkalinity, as measured by the calcium carbonate, was much higher on Sunday than during the remaining days of the week, the reduction during the working days being due to the entrance upon those days of acid solutions used as washes in certain factories.

Another diagram, Fig. 2, shows the increase and decrease of various constituents in the crude sewage, owing to monthly and seasonal conditions. Dissolved oxygen, nitrites and nitrates were constantly present in relatively large amounts. Throughout the year the dissolved oxygen value was very uniform, reaching a minimum in September and a maximum in March, the figures being 2.2 and 4.9 parts per 1,000,000, respectively. Variation in the nitrates was more marked than in any of the other nitrogen compounds, and the amount present apparently varied almost directly with the temperature, as is shown by the diagram. The average monthly nitrate value ranged from .37 parts per 1,000,000 in August to 2.60 parts in April and the nitrites from .04 parts in August to .22 parts in January. The oxygen consumed, chlorine and fats showed marked seasonal fluctuations.

The monthly variation and range in the chlorine-nitrogen ratios show a marked amplitude and distinct seasonal variations. The source of the chlorine is believed to be strictly normal, for no trade waste carrying an excess is known. The local normal chlorine number, as indicated by unpolluted surface waters, is low, approximating 2 parts per 1,000,000. The glacial drift upon which Waterbury is built does not contain salt deposits, although the ground water in certain localities doubtless carries a small amount of chlorine as a result of past pollution.

The hourly variation in the chlorine value, as shown in Fig. 3, is remarkable. The plotted curve has four decided crests, and these, owing to the rapidity of the sewage flow, show with clearness the principal source of the chlorine, as well as indicating the rising and retiring hours and general habits of the population of a manufacturing city.

A study of the fat content, or more specifically the ether-soluble matter, in crude sewage is one of the more recent additions to the list of regular determinations. A knowledge of the amount of fats present is of importance in view of its effect upon the scum and sludge deposits in septic tanks and its clogging influence upon sand filters.

The fats in the local sewage varied from hour to hour throughout the day, being relatively high at midday and low at midnight. A general daily variation occurred in which the fats were relatively high on Monday and Tuesday and low through the remaining days of the week.

The alkalinity read in terms of calcium carbonate ranged from 0 to 148 parts per 1,000,000, the yearly average being 41 parts. During one day in March, 1905, the sewage gave an acid reaction, equivalent to —5 on the alkalinity scale.

The sewage constantly contained iron both in solution and in suspension, but principally in the latter state, the amount present varying from 0.8 to 10.6 parts per 1,000,000, averaging for the year as follows: in solution 0.5 and in suspension 1.8 parts per 1,000,000. This comparatively small amount of iron has caused a marked discoloration of a fungus growth, which developed with rapidity upon the surface of sprinkling filters (the morphology and characteristics of this fungus described in Eng. News, Nov. 1, 1906). The coloring matter varied from a pale pink to salmon, and was shown upon maceration and washing to be ferruginous in nature and in the ferric state.

For practical working purposes of sewage

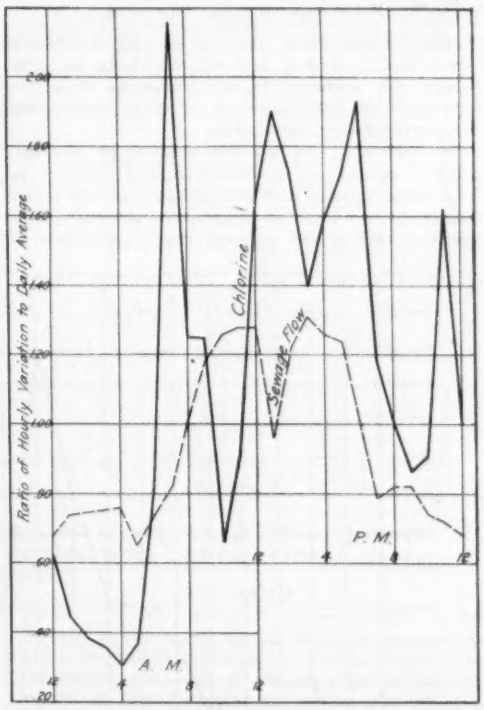


Fig. 3. Hourly Variations of Sewage Flow and Chlorine Value at Waterbury, Conn., November, 1905, to November, 1906.

purification the colloidal matter present in a sewage may be considered as the amount of suspended matter present in the effluent of a plain sedimentation basin when operated at a very low velocity. The amount of matter existing in the state of micro-suspension in the Waterbury sewage averaged, during the year, 84 parts per 1,000,000, as shown by the effluent of a 24-hour period settling tank.

Experiments in gallon bottles have shown that the colloidal matter present in the supernatant liquid, after a period of absolute quiescence for 24 hours, was 38.5 parts per 1,000,000 and the colloidal matter passing through rapid filter paper but caught by the asbestos mat in a Gooch crucible was found to be 15.7 parts per 1,000,000 as an average of six determinations.

The amount of bacterial life existing in the sewage, at the time of its discharge from the main carrier into the Naugatuck River at the site of the sewage disposal works, is comparatively small, being much less than is usual in city sewage at the outfalls. Gelatine plates incubated at 68° F. showed total counts varying from about 300,000 at 1 a. m. to about 1,600,000 at 2 p. m., and a daily average slightly above 700,000. The bacterial ratio varied almost directly with the amount of organic suspended matter carried by the sewage. The hourly variation in the bacterial life in the crude sewage is shown in Fig. 4.

That the number of bacteria existing in Waterbury sewage is very small when compared with counts made in certain other cities is emphasized by the figures:

City	Authority.	Year.	Av. number bacteria per c.c. of crude sewage.
Waterbury, Conn.	.....	1906	714,000
Boston, Mass.	Winslow	1904	1,240,000
Ames, Iowa	Walker	1901	1,248,000
Plainfield, N. J.	LeClear	1902	1,321,000
Lawrence, Mass.	Mass. St. B. H.	1894-1901	2,800,000
Columbus, Ohio	Johnson	1905	3,600,000
Worcester, Mass.	Eddy	1902	3,712,000
London (Crossness).	Clowes	1898	4,399,000
Walton, England	Boyce	1900	13,400,000
Belfast, Ireland	Smith	1903	15,300,000

The crude sewage was of a medium strength, substantially free from refractory trade wastes. Contrary to the local opinion that the sewage was highly acid, due to the entrance of acid pickles used as washes by the metallic manufacturing establishments, it was found to be alkaline. The extreme freshness of the sewage is emphasized by the fact that the organic matters are in relatively large pieces; that a great variety of organic matters can be readily distinguished and identified macroscopically; that the bacterial life pervading the sewage is very low in total counts; that the free ammonia number is low; that the ratio of organic nitrogen in suspension to the total is very high and that dissolved oxygen, nitrites and nitrates were constantly present in relatively large quantities.

Previous to the entrance of the screened crude sewage into either one of the two septic tanks it was passed through a grit chamber for the removal of the larger particles of mineral matter and such coarse, floating, suspended matter as would be likely to interfere with the gaging devices.

The character of the sludge accumulating within this grit chamber was that of a coarse, laminated, fibrous mass containing approximately equal amounts of mineral and vegetable matter, the former being principally road washings, the latter rags, coarse kitchen refuse and cellulose matter.

This coarse material accumulating within the grit chamber was so frequently removed that putrefactive changes never became so active as to cause the ebullition of gas. The volume and composition of grit chamber sludge in terms of wet sludge was as follows:

Cubic yards per 1,000,000 gals. of sewage	1.40
Tons per 1,000,000 gals. of sewage	1.12
Specific gravity	1.06
Water, %	88.3
Solid matter, %	11.7
Mineral matter, %	5.9
Nitrogen, %	0.22
Fats, %	0.78

Septic action of the crude sewage was studied for the purpose of determining the value of such treatment in preparing the sewage for filtration through sand and sprinkling filters and for its purification by means of contact beds.

Two tanks were used in the tests for septicization, each being 14 ft. long by 6 ft. 3 ins. wide by 6 ft. deep and containing about 4,000 gals. A third and similar tank was operated as a plain sedimentation tank for a comparison. Flow periods through these tanks ranged from 8 to 33 hours.

Tests were made upon the tanks to prove the uniformity of flow, by noting the passage of colored sewage and by a close comparison of analyses just before and after the interposition of an extensive baffling system in tank 2, with the result that no marked irregularity or non-uniformity of the flow could be detected. The actual flow rate within each tank was in substantial accord with the calculated flow period.

From Sept. 3, 1905, to Nov., 1906, screened crude sewage was continuously pumped into septic tanks 2 and 3, the calibrations of the flow periods being as follows: Tank 2, 16 hrs., Nov., 1905 to Jan. 20, 1906, and March 23 to Nov., 1906; 24 hrs., Jan. 20, 1906, to March 1, 1906; 33 hrs., March 1 to March 23, 1906; Tank 3, 8 hrs., June 6 to Nov., 1906; 16 hrs., Nov., 1905, to March 23, 1906; 32 hrs., March 23 to June 6, 1906. The tanks were not drained, neither was any of the sludge removed until the conclusion of the tests. A brief summary of results of opera-

tions under the schedule outlined is shown in Table II.

TABLE II.—AVERAGE COMPOSITION OF SEPTIC TANK EFFLUENTS, WATERBURY, CONN.
(Parts per million.)

	Flow period hours						
	Tank 3			Tank 2			
	8	16	32	16*	16†	24	32
Oxygen consumed	.38	36	31	36	35	35	32
Organic nitrogen	8.5	10.3	8.2	6.9	9.8	12.6	10.5
Free ammonia	11.1	9.0	11.8	11.0	11.5	9.5	8.9
Nitrites	.00	.52	.19	.41	.14	.25	.19
Nitrates	.00	.84	.23	.67	.54	1.18	1.24
Dissolved oxygen	.00	1.9	0.7	2.7	1.2	2.5	2.4

*Nov., 1905, to Jan. 20, 1906; †March 23 to Nov., 1906.

Observations upon the action of these tanks showed that they behaved in an unusual manner, most notably, perhaps, in the abnormally long time required to effect anaerobic conditions. At Columbus, Ohio (Report on Sewage Purification, 1905), it was found that the septic action was matured, if we consider such maturity as being shown by the first pronounced and continued ebullition of the gases of fermentation in the tank liquid taken in conjunction with the analyses of the effluent samples, in from 8 to 11 days, depending upon some function of the temperature, as may be shown by plotting a curve representing the time required for maturity. In evidence collected in England by the Royal Commission on Sewage disposal, Mr. T. W. Harding stated that several weeks passed before evidences of fermentation appeared in the tanks at Leeds, England. Mr. E. G. Mawbey, Leicester, England, stated that septic conditions "began in about three weeks; about from a fortnight to three weeks; if it was hot weather they began sooner than in the cold weather"; Mr. Gilbert J. Fowler, Manchester, England, stated that "in the course of a few days [the tank liquid] will begin to give off gas, but it will be by no means thoroughly septic before some months."

In the case of the test tanks receiving Waterbury sewage no evidence of fermentative actions, as marked by the ebullition of gas, occurred until about the middle of May, 1906, or until more than eight months after the starting of the tanks. At this time small bubbles began to appear, but the gas formation was not sufficiently pronounced nor the bubbles of such size as to admit of their being "flashed" by a lighted match until the middle of June. From June to September the intensity and violence of the putrefactive action rapidly increased and the ebullition of gas during this period was exceptionally active.

A surface scum did not appear upon the tanks between September, 1905, and May, 1906; during this latter month a growth of green algae spread over the surface. Beginning in June, with the increased activity of the gas formation, small masses of sludge were thrown up from the bottom, forming a series of thin, temporary surface scums, each of which was dissipated by the first wind or rain. Gradually the turbulence in the tank became more pronounced and the sludge masses dislodged from the bottom increased in size, until in July they were frequently as large as a waterpail. These large masses soon formed a deep, dense and tenacious surface mat which was persistent. A handful of timothy seed was scattered over the surface of one of the tanks in July, and the grass growing therefrom attained, before frost, a height of about 8 ins. The grass roots grew throughout the surface mat and bound it together into a tough mass which tenaciously held together.

Besides the apparent inactivity of fermentative actions within the tanks between September and June, as shown by the absence of gas formation during that period, further proof may be shown by a study of the chemical data. The daily analyses of the crude sewage during the September-to-May period invariably showed the presence of nitrites, nitrates and dissolved oxygen in considerable quantities. In fact, during the entire period covered by the tests, even in mid-summer, these three constituents were almost invariably present in the half-hourly and daily composite samples of crude sewage.

Throughout the colder months the parts per million of each have been higher than during the warmer months. The effluents of both septic tanks 2 and 3 upon analysis showed that previous to June all three of the constituents under discussion were present, although reduced in amount from that found in the crude sewage. The presence of available oxygen in the form of nitrites, nitrates and dissolved oxygen (Fig. 5 and Table III.) in the effluents of the septic tanks obviously proves beyond a doubt that anaerobic conditions had not been established throughout the tanks and that the putrefactive and hydrolysing actions were feeble.

TABLE III.—DISSOLVED OXYGEN, NITRITES AND NITRATES IN WATERBURY SEWAGE AND SEPTIC TANK EFFLUENTS.

	Crude sewage			Septic effluents		
	Dis. oxy.	Nitrites	Nitrates	Dis. oxy.	Nitrites	Nitrates
Yearly average (Nov., 1905, to Nov., 1906)	3.8	0.14	1.52			
Seven months (Nov., 1905, to May, 1906)	4.5	0.18	2.18	*3.9	0.14	1.71
				†3.6	0.14	2.10

*Tank 2; †Tank 3.

That tanks could receive sewage constantly from Sept. 3 to May 1 of the next year, as these tanks did, without the establishment of active putrefactive conditions is a most interesting and remarkable occurrence.

In searching for an explanation of the unusual amount of available oxygen present in the crude sewage and the effluents of the septic tanks, in the form of oxygenated nitrogen compounds and in the gaseous state, the mode of sample collection and preservation, and the technique of the analyses were subjected to elaborate checks until definite and absolute proof of the correctness of the results was established. The flows through the tanks were studied until it was shown that the actual flow period did not materially differ from that calculated by the flow passing the gaging device, and an efficient system of baffles and scum boards was constructed in tank 2 which absolutely prohibited the sewage from passing through in any other than the rated period of time. The interposition of this baffling system did not effect, in the least, a change in the character of the effluent, nor did it assist in the promotion of putrefactive actions. A study of the average monthly analyses of tanks 2 and 3 shows that the anaerobic conditions were less complete in tank 2 than in tank 3 even in the face of the fact that the latter tank did not have a baffling system and that it was operated during the summer at twice the rate of the former.

As an explanation of the non-activity of putrefaction or fermentation in the sewage and the extreme slowness with which its available oxygen was exhausted, Table IV. has been prepared from data contained in the daily analyses of the crude sewage. The table shows by months, the amount of nitrites, nitrates and dissolved oxygen in the sewage and also oxygen consumed value as measured by three-minute contact with an acidified solution of permanganate at room temperature or its equivalent value, 20% of the 5-minute boil, the oxygen available in the oxygenated nitrogen compounds and in the dissolved gaseous state. Two ratios are shown: first, the existing between the available oxygen in nitrites and nitrates and the oxygen consumed value, and second, that existing between the oxygen available in the form of nitrites, nitrates and dissolved oxygen and the oxygen consumed value. The highness of these ratios during the colder months amply explains, it is believed, the feebleness of the putrefactive action.

TABLE IV.—AVERAGE AMOUNT OF AVAILABLE OXYGEN IN WATERBURY CRUDE SEWAGE AS DISSOLVED OXYGEN AND OXYGENATED NITROGEN COMPOUNDS.
(Parts per 1,000,000.)

Month, 1906.	Available oxy. as nitrites and nitrates	Oxy. consumed	Ratio, Col. 1 ÷ Col. 2	Available oxy. as nitrites and dis. oxy.	Ratio, Col. 4 ÷ Col. 2
Jan.	6.1	9.2	66	10.8	117
Feb.	4.47	8.0	56	8.11	101
March	7.00	8.8	79	11.7	133
April	8.01	8.4	95	12.11	144
May	5.35	8.8	61	8.45	96
June	2.43	8.4	29	6.03	72
July	1.69	8.6	20	4.69	55
Aug.	1.27	9.0	14	3.87	43
Sept.	2.54	10.4	25	4.74	45
Oct.	5.18	11.8	44	8.58	73

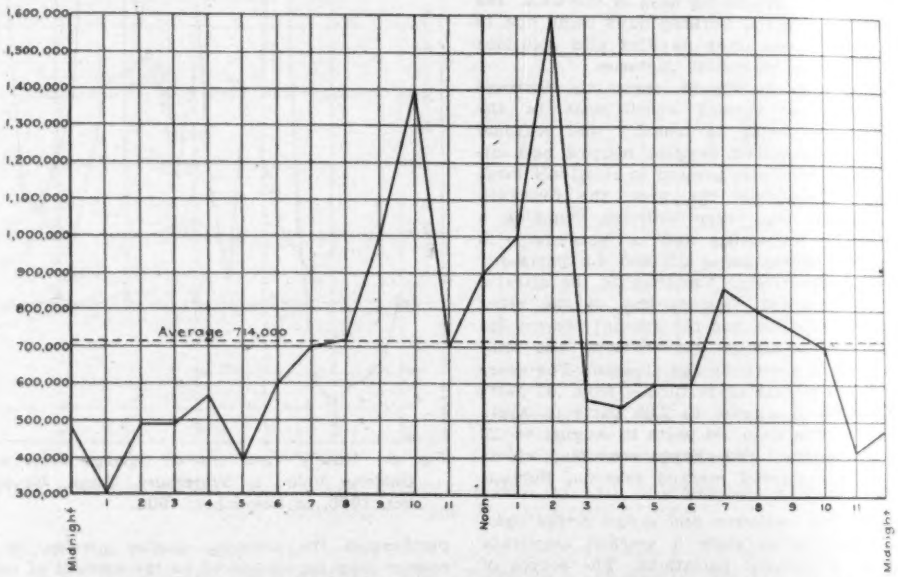


FIG. 4. VARIATION OF BACTERIAL LIFE IN THE SEWAGE OF WATERBURY, CONN.
(Total Counts on Gelatin.)

As further evidence bearing upon the time required for the exhaustion of the available oxygen and the establishment of putrescent conditions it may be said that 4-oz. samples of crude sewage collected during the winter of 1906 and incubated for 24 hours at 98° F. still contained a small amount of available oxygen and were free from the characteristic putrescent odors or discolorations. The samples would, however, break down at the end of 30 or 33 hours incubation and show at that time a blackening, a depletion of the available oxygen and the presence of hydrogen-sulphide.

Observations upon the Naugatuck River substantiate the results of the above tests. The stream is grossly polluted and during periods of dry weather about one-third of the flow reaches it through the city sewers. Except during the months of July, August and September the nuisance caused by the polluting wastes is not apparent by odors or gases arising from the putrefaction of the organic matters.

A test was made March 14-17 upon tank 2 to show exhaustion of the dissolved oxygen. The tank influent was stopped at 8 a. m. March 14

and started again at 8 a. m. March 17, the retained liquid being held in a state of quiescence. Table V. shows that the available oxygen was exhausted at the end of 22 hours. The free ammonia increased slightly, with a corresponding decrease in the organic nitrogen. Upon the resumption of the influent flow the anaerobic conditions rapidly disappeared and the effluent returned to its normal quality.

TABLE V.—TEST FOR OXYGEN EXHAUSTION, SEPTIC TANK 2.

Date	Nitrites	Nitrates	Dissolved oxygen
March 13, 8 a. m.	0.22	.91	3.0
*March 14, 8 a. m.	0.04	.26	3.6
March 14, 6 p. m.	.02	.22	2.5
March 14, 12 mid.	.01	.23	.30
March 15, 6 a. m.	.00	.00	.00
†March 17, 8 a. m.	.00	.00	.00
March 17, 12 mid.	.00	.00	0.8
March 18, 8 a. m.	.14	.79	2.0
March 19, 8 a. m.	.20	1.29	4.1

*Influent shut off; †influent flow resumed.

In Fig. 5 it is shown that an exhaustion of the dissolved and other available oxygen from the septic tanks did not occur until June. Following this exhaustion the ebullition of gas became violent, causing great turbulence within the tank. The incessant upheavals of gas, during this period of accentuated putrefactive action, put into suspension much finely divided organic matter, the complete exclusion of which from the effluent was practically impossible. This abnormal action of the septic tanks under the Waterbury conditions makes their control much more difficult than is generally the case, for throughout the colder months they operate practically as plain sedimentation tanks, the action of which is succeeded by a most violent fermentation during the summer months.

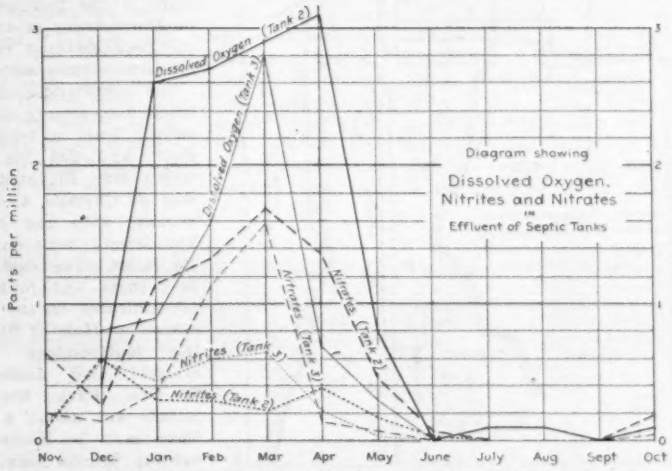


FIG. 5. DISSOLVED OXYGEN, NITRITES AND NITRATES IN EFFLUENTS FROM EXPERIMENTAL SEPTIC TANKS, WATERBURY, CONN., 1905-6.

The sludge accumulating within these tanks during the first eight months of their operation had a coarse, fibrous texture, and a dark, grayish color and showed the result of but a small amount of bacterial action. In November, however, after the period of intensified bacterial action occurring throughout the summer, the sludge was well digested, finely divided and jet black. The composition of the septic sludge and scum is shown in Table VI.

TABLE VI.—COMPOSITION OF SEPTIC TANK SLUDGE AND SCUM.
(In terms of wet material.)

	Sludge		Scum
	Tank 2	Tank 3	Tank 2
Weight per cub. yd., lbs.	1,721	1,738	1,637
Specific gravity	1.02	1.06	0.97
Water, %	86.3	85.4	80.9
Total solids, %	13.7	14.6	19.1
Volatile matter, %	5.9	7.	8.9
Nitrogen, %	0.16	0.22	0.34
Fats, %	1.53	1.52	2.00

The average flow periods of tanks 2 and 3 was 15.5 and 11 hours, respectively, the horizontal velocities being .08 and .11 mm. per sec. At the conclusion of the tests tank 2 held 1.07 and tank 3, 0.55 cu. yds. wet sludge per 1,000,000 gals. of sewage passed through. In each tank there had been deposited 0.25-ton of dry solids per 1,000,000 gals. of sewage treated, and of this 50% was retained in tank 2 and 36% in tank 3 at the conclusion of the tests.

The operation of these test tanks shows that once each year it is desirable, under the local conditions, to remove the major portion of the accumulated sludge. The disposal of this sludge may be readily accomplished by either one of two principal methods: (1) its discharge into the Naugatuck River during freshet periods and (2) its treatment upon sludge filter beds. The flood flow of the Naugatuck River is sufficiently great to receive the sludge deposits without setting up adverse conditions or creating odors of putrefaction along or in the river. Samples of the flood water mixed with the sludge in the proportion of 1,650 parts of the former to one of the latter produced a mixture without apparent odor and which proved to be non-putrescible upon incubation. If, however, for aesthetic or other reasons it is ever desirable, the septic sludge may be pumped upon sludge beds for filtration and drying or given other treatment.

In purifying Waterbury sewage the conditions are favorable for the non-production of odors from septic tanks or the liberation of foul smelling gases upon the diffusion of the tank effluents over the surface of sprinkling filters. Oversepticization of the tank effluent is not likely to occur under normal operation. This together with the fact that sulphides and sulphates are practically absent in the sewage, places it beyond the control of these important causes of foul odors in the operation of septic tanks.

The tanks were uncovered and were operated in full exposure to the weather. Ice occasionally formed upon the surface to the depth of ½-in., but it was not persistent. The amount of ice present in the tanks during the tests was not as great as would occur in a normal winter, for the reason that the air temperature during the winter of 1905-6 was 8° higher than in the preceding five winters.

Under the same conditions that governed the septic tanks, tests were made with a plain sedimentation tank. The sludge was removed so frequently from the sedimentation tank that septic action never became established. The adaptability of the effluent from the sedimentation tank so far as its subsequent purification by filtration is concerned, has been substantially upon a parity with the more or less completely hydrolized effluents from the septic tanks. The principal advantage in the use of septic tanks under the local conditions appeared mainly in the economic disposal of the accumulating sludge.

The practicability of successfully treating the effluent from plain subsidence basins upon sand or sprinkling filters at high rates has much value in the present instance, as it admits of the efficient purification of the sewage almost from the time of filling the basins, the only lost time being that required in the development of the biological construction in the filters. Since Waterbury is under obligation to purify its sewage wastes only during the months between May and November, it is evident that through this parity of effluents the annual cost of pumping is greatly reduced, and further it is practicable to operate tanks at flow periods of 16 hours or less, whereas if a much more perfectly hydrolized effluent was required the flow period would necessarily exceed 32 hours.

These sewage studies have been carried out under the direction of the Board of Public Works, Mr. R. A. Cairns, M. Am. Soc. C. E., City Engineer, with the writer in immediate charge of the experiment station and the design and construction of the purification works, and with Mr. Harry B. Hommon as chemist.

Steel and Iron Tubes for Locomotive Boilers.

A direct contrast of opinion and experience as to the respective advantages of steel and iron tubes for locomotive boilers was presented in a report read at the annual meeting of the International Master Boiler-Makers' Association at Louisville, in April. The report consisted mainly of personal statements, from which we extract the following:

Mr. B. F. Sarver (Pennsylvania Lines, Fort Wayne, Ind.).—Many of the large railway systems of this country are using almost exclusively the seamless cold drawn tubes for safe ends. A great many of the roads have large quantities of charcoal iron tubes in service, and in looking this matter up, I find they weld very readily into steel.

It is generally understood that the end of the tube, especially the firebox end, has to stand the most severe punishment and if the railways have selected the seamless tube for the purpose of safe ends, they must recognize in it a quality superior to iron. I cannot see why, at a less expense than iron, it would not be the most economical body tube for locomotives.

One of the lines with which I am connected uses steel tubing for safe ends exclusively. Since the adoption of steel at this particular place they have increased their flue mileage at least 24%. The maintaining and calking of flues in the engine-house has also been reduced 25%. I have experienced no difficulty whatever in welding the steel safe ends to iron flues.

Below are the figures for five passenger and five freight engines, with the mileage made with iron tubes, as well as with steel safe ends that we applied.

Mr. Clement Ryan (Union Pacific Ry., Omaha, Neb.).—In my opinion, iron is the best for all purposes, especially as regards pitting. We have had a great deal of experience with both iron and steel tubes, and find the steel so badly pitted after a service of from 8 to 12 months as to necessitate 75% of the tubes being scrapped. Iron tubes in engines running over the same district and under the same water conditions last for years. I would recommend the use of iron tubes with steel safe ends, as the steel safe ends in fireboxes stand the heat better than iron. It is standard practice on the Union Pacific Ry. to use iron tubes with steel safe ends for firebox, and the results have been good.

The welding of steel and iron tubes requires a good deal of attention as the heating of these two metals is not the same, and we have had a good deal of trouble in welding steel safe ends to iron flues. We would find after the weld was made that at a point about ⅛-in. from the weld the steel would be cracked, sometimes half way around the tube. To overcome this difficulty, after the steel piece has been fitted to the tube and put in the fire, it should never be removed until it is ready to weld, because if it comes in contact with the air and is then replaced in the fire, a certain proportion of the welding property is destroyed.

A DUPLEX ARTICULATED LOCOMOTIVE having two swiveling steam trucks on the Fairlie system has been built by Kitson & Co., of Leeds, England, for the Leopoldina Ry., of Brazil. This line is of meter gage. The arrangement of the steam trucks is peculiar; the front one being under the boiler, while the rear one is behind the firebox and under the cab and front part of the tender. The wheel arrangement, including both engine and tender, is of the 2-6-6-4 type. Both trucks are high-pressure steam, and the exhaust from the cylinders of the rear truck is discharged through a stack or chimney in the tender. Water is carried in tanks on each side of the boiler as well as in the tender. The four cylinders are 14 x 18 ins., and the driving wheels are 34¼ ins. diameter. The wheelbase of engine and tender is 42 ft. 2 ins. The tender carries 3,000 gallons of water and 5 tons of coal briquettes.

DATA ON IRON AND STEEL TUBES FOR LOCOMOTIVE BOILERS.

Passenger			Freight		
Mileage with iron flues.	Mileage with steel flues.	Increase for steel.	Mileage with iron tubes.	Mileage with steel tubes.	Increase for steel.
60,299	108,478	48,179	33,260	55,063	21,803
96,273	103,350	7,050	39,390	76,788	37,398
41,684	115,723	74,039	46,371	54,639	8,268
50,128	87,524	37,396	36,614	59,967	29,353
84,561	120,088	35,527	28,130	50,014	21,884

The Report on a Proposed Subway System for Street Cars and Elevated Railway Trains in Chicago.

The idea of building subways for rapid transit purposes in the business district of Chicago is an old one, and has been embodied in a number of rapid transit schemes put forward by the municipality and by outside private interests during the past 20 years, or more. Some of these projects are noted at the end of the present article. In most (if not all) of these schemes the object has been to relieve the traffic congestion in the streets by removing the street cars (or a large proportion of them) from the surface, and not to establish an underground railway independent of the surface facilities (as at New York). In the recent plans, this system is extended to include the trains of the elevated railways. It has been suggested that if all these trains can be accommodated in the subway, in addition to the surface cars, the unsightly and in many ways objectionable structure of the elevated terminal loop may be removed from the crowded streets of the business center. This, however, does not appear to be probable.

In April, 1908, the mayor, Mr. Busse, sent to the city council a communication in which he suggested that it was time for the city to take up seriously the question of underground transportation. At his recommendation the matter was referred to the council committee on local transportation. That committee requested the Commissioner of Public Works to have an investigation made, so that a plan for the construction of subways could be formulated and submitted to the council. It was specified that the work should cover the district bounded by Lake Michigan, Halsted St., Chicago Ave. and 12th St., and that it should provide as follows:

> The development of a scheme for subways, which may be extended as conditions require. This shall be used not only for transportation purposes, but also to house publicly-owned and privately-owned utilities; to carry water, sewer and high-pressure fire service lines; to provide space for the reception of such other underground installations as may be desirable, and to afford space at stations for public comfort stations and other public conveniences.

It was specified also that the investigation should cover the following related matters: (1) public and private occupancy of sub-sidewalk space; (2) the water and sewer systems, with their maintenance during construction, and their necessary alterations; (3) the introduction of a high-pressure water-supply system for fire protection in the business district; (4) building foundations of the present and future; (5) the systems of public-service utilities occupying the streets.

The work of carrying out the investigation was entrusted to Mr. John Ericson, M. Am. Soc. C. E., City Engineer. For this purpose he organized a special subway division (in the Bureau of Engineering), with the late Thomas T. Johnston as Chief Assistant Engineer in charge of the division. Mr. E. C. Shankland was engaged as consulting engineer in matters of building foundations, sub-sidewalk occupancy, excavation, etc. Among the engineers in charge of the more important sections of the division were the following: T. H. Williams, foundation and sub-sidewalk space; James W. Pearl, construction details; H. S. Baker, office assistant engineer; R. C. St. John, traffic and miscellaneous work; E. F. Norton and Henry Hermann, electrical utilities; D. W. Maher, telegraph utilities; C. C. Prince, telephone utilities; F. T. Pierce, gas utilities; C. I. Jones, high-pressure water system; F. E. Borg, bridges; W. Putnam, miscellaneous; J. H. Sawyer, in charge of drafting room. The subway design now submitted was prepared as the result of frequent conferences of the engineering staff, at which questions were discussed in their various relations.

The general report (comprised in three bulky volumes) was completed and presented to the council committee on local transportation in March. It now remains for this committee to take it up for consideration, and to decide as to further action in the matter. Another report, supplementary to the one above mentioned, will be made to the committee later. This will deal with a system sufficient for a city with a population of about 6,000,000.

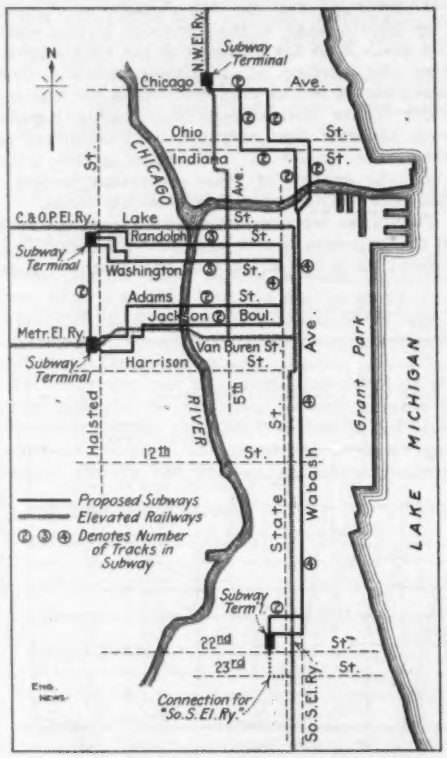


Fig. 1. Map of Proposed Subways for Surface Cars and Elevated Railway Trains in Chicago.

In regard to the traffic development, the rapid growth of population is an important factor. The population of the Chicago center (including the whole of Cook County and some contiguous districts) is given by the report as 2,172,000 for 1906, and is estimated to increase to 6,000,000 by 1950. Statistics indicate that the rate of increase in the number of passengers on urban transportation systems is much greater than the increase in population. The number of rides per capita increased from 100 in 1885 (with a population of about 850,000) to 230 in 1908 (with a population of 2,300,000). It is estimated that this will increase to 404 by 1940, at which time the revenue (with fares unchanged) would be about $110,510,000. The estimate of conditions for 1920 is as follows: population, 3,459,300; rides per capita, 296.30; total number 1,024,990,000; revenue, $51,249,5

The city fronts upon Lake Mic develop only on three sides. T and west sides form separate having special features of trans ties and having main lines of which enter the business district down-town surface lines have st minals in this district, an arra tends to aggravate the congestion is only recently that a few throu been established, with surface ca one district to another and trav (instead of reversing in) the business c Through routing by the elevated railw has been strongly advocated, but not yet a by the companies.

The general plan for the comme ment of a subway system, as proposed by t report and shown in Fig. 1, provides for thre main subways: (1) a north-and-south line extending along the eastern side of the business district; (2) two east-and-west subways forming loops connecting the business district with the west side of the city. A special feature of the arrangement is the location of four subway terminals at the margin of the business district, serving the four elevated railways and also a number of surface lines which converge at these points.

The north-and-south subway would be a four-track line, mainly along Wabash Ave. It would extend from a terminal on the south side at State and 22d Sts., for connection with the South Side Elevated Ry., to one on the north side at Chicago Ave. and Orleans St., for connection with the Northwestern Elevated Ry. The length between terminals would be about 3½ miles. The east-and-west lines would have two, three and four tracks at different points (as indicated on the map), and would reach terminals at Halsted St. and Blue Island Ave. (for the Metropolitan Elevated Ry.), and at Halsted and Lake St., (for the Chicago & Oak Park Elevated Ry.). These terminals are about a mile west from State St. They may be connected by a north-and-south subway ¾-mile long, for additional convenience in distributing the traffic. There will be no controlling grades, except where the lines are depressed to pass under the river. The exact location of the terminals and connections would be determined later.

The subways now proposed (as described above) would constitute the beginning of a comprehensive system, to be developed as the growth of the city may require. The report states that these alone cannot be expected to provide adequate transportation for any considerable future period, and that their construction must be followed (at an early period) by subways taking advantage of other outlets from the business district. It is to be noted, however, that while additional east-and-west subways could be built without difficulty, any additional north-and-south subway would involve the alternatives of low-level construction or numerous grade crossings of the east-and-west lines.

The subways are designed particularly to accommodate the long haul traffic between the business center and the residence districts, and not for the local traffic within the business district. It is not intended to divert all the elevated trains and surface cars into the subways, but only a sufficient number to relieve the con-

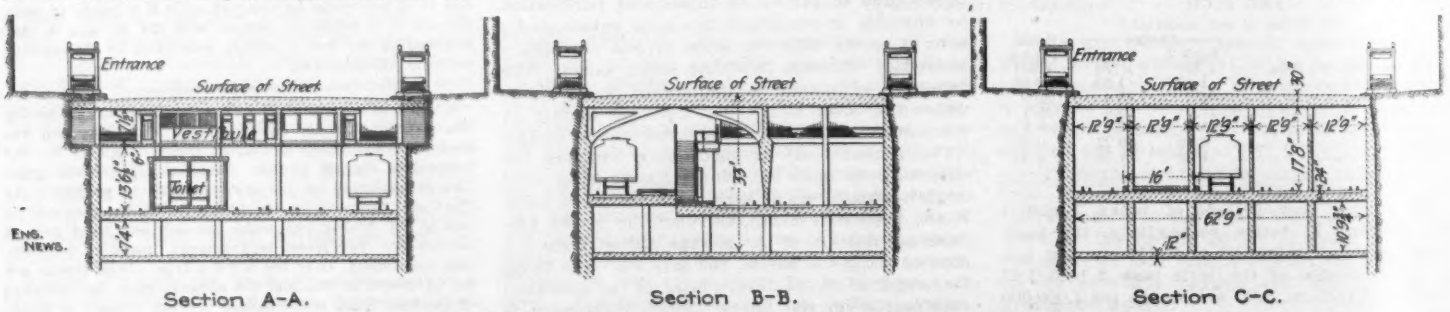


FIG. 2. CROSS-SECTIONS OF PROPOSED CHICAGO SUBWAYS (FOUR-TRACK).

gestion of the business district, together with such additional cars or trains as may be required for passengers desiring to use the subways. The main traffic objects in view in the design for initial subways were: (1) maximum car and train capacity; (2) free and convenient carrying of passengers; (3) provision for any ultimate through-route facilities.

It is stated in the report that the Chicago subways are intended primarily to relieve the congestion of traffic, and that they will provide an improvement in rapid transit only to the extent that they facilitate the passage of cars across the congested district. The requirements for transportation are increasing continually, and the subway construction should be kept well in advance of these requirements. If the subways are only enough to meet the increased facilities at the time of their construction, the conditions of surface traffic will not be relieved but will become more congested by additional traffic due to the growth of the city.

The complete removal of the local transportation lines from the street surface is at least unlikely, as there will be increasing need for such lines to transport passengers over short distances within the subway zone, and to some extent without the zone. It may be said in general that, in view of the fact that subway transportation cannot ultimately meet the requirements that will follow the present order of development, the use of subways (while providing as fully as possible for purely local traffic) should be for the outlying residential districts rather than for that comparatively minor traffic pertaining to the short distances within the subway zone itself.

As to the traffic capacity, the report states that the north-and-south subway has a capacity for comfortably carrying 18,000 passengers per hour in each direction on the two tracks for surface cars, and 25,000 per hour in each direction on the two tracks for elevated railway trains. This is based on the hourly movement of 240 surface cars and 50 trains of seven cars each. This gives a total movement of 86,000 passengers per hour, or a 50% addition to the carrying capacity of the present local transportation lines. The passengers who will contribute to this traffic will be made up as follows: (1) the element escaping from the present congestion; (2) the increase due to the additional facilities; (3) the increase due to the growth between the present time and the time of opening the subways for operation. It is considered as quite probable that if only one subway is constructed:

It will be found to be carrying passengers to its comfortable capacity as soon as completed, without in any degree relieving the present state of congestion.

Among the factors considered in the design of the subway system were the following: (1) relief of congested traffic; (2) provision for future traffic; (3) effect on real estate; (4) underground public service utilities; (5) interference with buildings and foundations; (6) cost of construction; (7) procedure in construction; (8) shallow, double-deck and low-level subways; (9) local traffic in the business district; (10) routing of cars and trains; (11) rapid transit; (12) ventilation and noiselessness; (13) transfers; (14) traffic now waiting to be accommodated, and traffic development; (15) accommodation of contributory population in outlying districts.

One of the important features of the investigation has been the collection of information relative to the physical conditions and the underground obstructions. These matters include the following: water supply, sewers, gas, telephone and telegraph, electric light, city electric utilities, sub-sidewalk space, building foundations and sub-soil, miscellaneous occupancy of streets and alleys, the freight tunnel system, occupancy of property for railways, high-pressure water-supply system, and bridges and viaducts. As to the sub-surface utilities, the information already gathered for the report shows conditions of confusion and congestion, due to lack of system and cooperation. In fact, with present methods unchanged: "The time may soon come when there will not be room in the streets to carry the utilities required."

System of Construction.

The city streets have widths of 100 ft., 80 ft. and 66 ft. between building lines. The width of subways as planned for four, three and two tracks, would be about 65 ft., 53 ft. and 42 ft., respectively, thus leaving ample width on each side for sub-sidewalk space. Projects have been suggested for subways in opposite directions crossing each other at different levels. The report states, however, that a comprehensive low-level subway seems to involve such great construction difficulties, such great cost, and such "extreme danger" to the foundations of buildings during construction, as to be impracticable.

BUILDING FOUNDATIONS. — The subway construction will be mainly in clay, and a special investigation of the building foundations in relation to the soil and the construction of the subway was made for the purpose of the report by Mr. E. C. Shankland, M. Am. Soc. C. E. We shall give some further particulars of this later. It presents the following results: (1) Old buildings having dimension stone footings will involve care, but are being replaced so rapidly in the business district that they are not an important factor in the subway problem. (2) Buildings with spread foundations must be underpinned or otherwise taken care of; in individual cases the cost will be considerable, but the total will be but a small percentage of the total cost of the subway. (3) Buildings on piles have piles which reach below the bottom of the subway, and these would involve very little trouble. (4) Buildings having the modern foundations of solid concrete piers carried down to rock or hard-pan would cause no trouble, as the piers are carried far below the subway.

These statements are based upon the assumption that the bottom of the subway will be not more than 18 or 19 ft. below the city datum (river level). This would give all the depth required for a single-deck subway and a gallery for public service utilities. It would also clear the freight tunnels, the crown of the arch of these being about 19 ft. below datum.

TYPE OF CONSTRUCTION.—The type of construction adopted (or recommended by the report) is a shallow rectangular subway of reinforced-concrete construction, utilizing all the space available between the curb walls, the street surface and the freight tunnels of the Illinois Tunnel Co. The shallow system provides against endangering the foundations of buildings. The use of concrete is considered to reduce the cost and difficulty of construction, and to reduce the noise due to traffic. The subway would have two, three and four tracks at different parts. A different form of construction would be required, of course, where the lines pass under the Chicago River. At such points single-track tube tunnels would be used. The general character of the design is shown by the sections in Fig. 2.

At stations there would be platforms 16 ft. wide, accommodating a nine-car train on each side. Maximum efficiency with minimum width of subway is claimed for the arrangement of island platforms located alternately between the two tracks used by the elevated railways and the two used by the surface lines, as indicated by the plan in Fig. 3. Passengers from the trains ascend by stairways to a longitudinal gallery over the platform, thus avoiding the passengers waiting on the platform. At each end of the station (and at the middle of the block) is a transverse gallery or vestibule, at each end of which are two stairways to the street. This provides a place for ticket offices, news-stands and other station facilities, and also serves as a subway by which the general public can cross the street in safety. The longitudinal gallery opens onto this vestibule, and stairways lead from the vestibule to the train platforms. With this arrangement the length of continuous stairways is reduced. Public comfort stations would be provided at all these stations. The arrangement of the station and its facilities is shown in Fig. 3.

The gallery for the accommodation of public service utilities is located beneath the train floor.

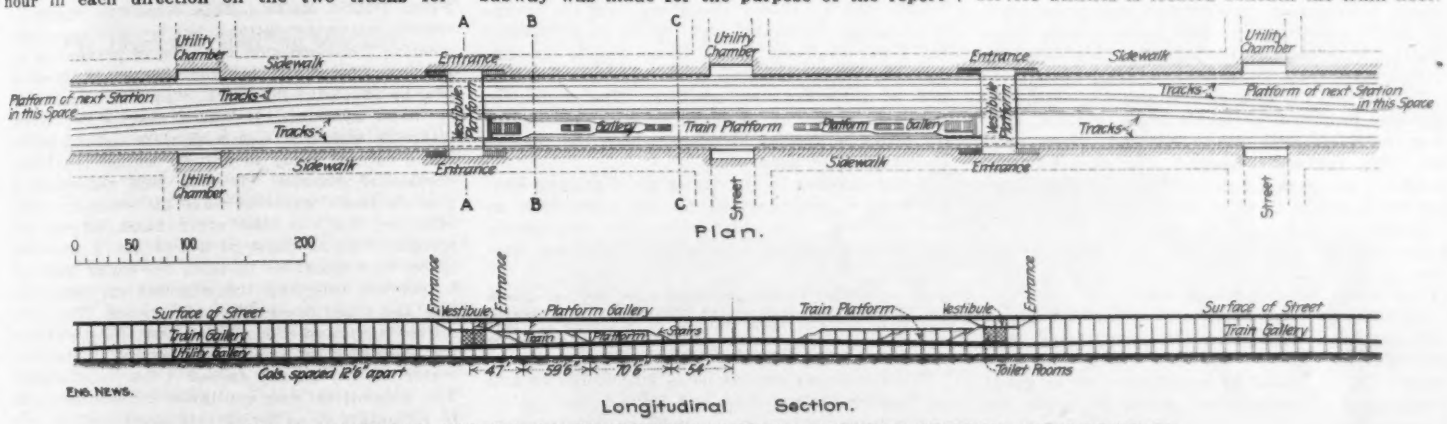


FIG. 3. PLAN AND PROFILE OF FOUR-TRACK SUBWAY, SHOWING STATION ARRANGEMENTS.

It is divided into five longitudinal compartments about 11 ft. wide and from 6 ft. to 8 ft. in height. The grade of the train floor is so arranged at stations as to give additional height at important street intersections where valves, etc., may make this necessary. The columns of this gallery would be about 12 ft. apart longitudinally. At the street intersections, a vertical shaft or chamber at each side of the subway would extend from the bottom of the gallery to the street surface (Fig. 3), so as to allow of connections between the utilities in the subway and those in the cross streets. The gallery may be ventilated by electrically-driven exhaust fans placed in these chambers.

Transverse concrete girders resting on side walls and on the columns of the utility gallery would support the track stringers and platforms. In the main or upper part of the subway columns would be used normally to support the roof. At curves and stations, however, it is proposed to dispense with columns and to support the roof by three-hinged arches of concrete, as shown in Fig. 2. The report states that a large proportion of the work would consist of duplicate parts that may be fabricated at some convenient place and brought to the work ready to be set in place. It is believed that this would materially reduce the time and cost of construction.

LOADS.—The loads assumed are as follows: (1) For the train floor; two adjacent 30-ton motor trucks with axles 5 ft. apart, and a train load of 50-ft., 50-ton, double-truck cars with trucks of 6 ft. wheelbase. (2) For the vesti-

buies, stairs and platforms; a moving load of 110 lbs. per sq. ft. (3) For the utilities gallery; conduits weighing 3,000 lbs. per lin. ft. in each compartment. (4) For the roof; A, a truck load of 40 tons on four wheels 20 ft. apart and 5-ft. gage; B, a load of 40 tons uniformly distributed upon any rectangular area of 160 sq. ft.; C, a load of 500 lbs. per sq. ft. upon 25% of the paved width of street adjacent to the curb line (to provide for building operations); D, a uniform moving load of 300 lbs. per sq. ft. on all street surface not covered by the previous loads.

COST.—The cost is estimated as follows: Four-track subways, $3,750,000 per mile; three-track, $3,375,000; two track, $3,000,000; single-track tunnels under the river, $800,000 per mile. The cost of caring for the foundations of buildings is estimated at $200,000 per mile on the north-and-south line, and more than this for the east-and-west lines.

Earlier Projects.

For the information of readers who may be interested in the development of the several subway projects at Chicago, we give below some notes of the principal articles on this subject which have appeared in our columns.

Aug. 9, 1900 (p. 85).—Double-track shallow subways proposed by the street railway companies, each with down-town terminals (no through connections). Cost estimated at $1,000,000 per mile, or $2,000,000 with pipe subways.

Jan. 31, 1901 (p. 88).—Deep level subways proposed by W. H. Rosencrans. Tunnel 28 ft. diameter, with a minimum depth of 16 ft. from street to crown of arch. There was to be a belt or loop around the business district, with intersecting lines inside, and branches outside to the surface.

July 17 and 24, 1902 (pp. 44 and 65).—Mr. John Ericson proposed a double-track shallow subway with galleries for pipes and wires. Mr. Geo. W. Jackson proposed single-track deep-level tunnels forming down-town terminal loops for the different lines of street railways.

March 24, 1904 (p. 279).—The city proposed to build loops from each of the three river tunnels through the business district, and to lease them to the street railway companies.

Dec. 22, 1904 (p. 568).—Mr. Geo. W. Jackson proposed a combination of single-track and double-track shallow subways (with pipe galleries). There would be no intersection or grade crossings, but connections would be made for through routing.

Aug. 24 and Oct. 5, 1905 (pp. 207, 351 and 355).—The subsidence of streets and settlement of buildings in connection with tunnel construction was discussed.

July 19, 1906 (pp. 73, 79).—Mr. B. J. Arnold proposed low-level north and south lines and a high-level loop for east and west lines. This would provide for connections and transfers, but would involve no grade crossings.

March 7, 1907 (p. 255).—The lowering of the street railway tunnels under the Chicago River.

THE FEDERAL FINE ARTS COUNCIL appointed by President Roosevelt the early part of this year (Eng. News, Jan. 28, 1909, p. 117) has been abolished by executive order of President Taft. This council, composed of a number of leading architects and artists of the country, was supposed to have a supervisory power in the selection of all sites and designs for public buildings, monuments and parks. Its members, who served without salary, had no original power in the determination of what public expenditure of funds should be made or of what buildings should be erected, but only in the selection of artistic and proper designs for such structures as should be authorized by Congress. The order revoking the Commission to the Council is in accord with a provision of the Sundry Civil Bill passed by the last Congress, which forbade the appointing of such commissions as the Fine Arts Council, the Country Life Commission and the Conservation Commission without the authorization of Congress. In signing the bill Mr. Roosevelt claimed that Congress was without authority to make any such restriction of the executive power, but Mr. Taft, in revoking the Fine Arts Council, seems to think differently. It remains to be seen whether the other presidential commissions of the recent administration will be continued or abolished.

Annual Meeting of the National Fire Protection Association.

The National Fire Protection Association held its 13th annual meeting in New York City on May 25 to 27, 1909. The six sessions, which were held at the headquarters of the New York Board of Fire Underwriters, 32 Nassau St., were occupied almost wholly with the reports of various technical committees. Most of the committees limited themselves to reporting "Progress," and while there was no lack of discussion and considerable evidence that the committees and the association are seriously at work, very few definite results were produced.

The committee on Manufacturing Risks and Special Hazards has distributed its work among individual sub-committees, each charged with investigating risks in the processes of manufacture of a special industry and recommending means for reducing or eliminating hazards where possible. None of these sub-committees has yet reached the point of reporting anything definite.

The committee on Devices and Materials limited itself to outlining the facilities and work of the Underwriters' Laboratories Inc. The equipment of the laboratory has been enlarged materially during the past year.

The subject of Fire Protection Coverings for Window and Door Openings, which will engage its committee actively during the coming year, seems to be mainly a task of unifying the divergent standards, requirements and preferred practices of different parts of the country. Two details led to some discussion: the location of fusible link in sliding fire-doors, and the means of securing reasonably tight fit of metal-covered wood fire-shutters. Both these details promise difficulty in formulating a recommendation that will be universally satisfactory. The committee will also endeavor to recommend standards for fire-doors in special locations where the regular style cannot be used, etc.

Minor changes in the Rules for Signaling Systems were recommended by the committee on this subject. The chief alteration was adding the specific recommendation that auxiliary fire-alarm boxes

must be located in conspicuous places, easy of access and as near as practicable to floor exits. A sufficient number of boxes must be provided so that from any part of the plant equipped not over 200 ft. will have to be traversed in order to reach a box.

There were no reports on Grain Elevators and on Theater Construction and Equipment.

The three committees on building construction, viz., Conference on Building Code, Fireproof Construction and Concrete and Reinforced Concrete for Building Construction, of each of which Mr. E. T. Cairns is chairman, presented only progress reports. The chairman reported that all of these subjects are under consideration by committees of societies more directly concerned with building construction, and that until these latter committees reach some definite agreement it is useless for the National Fire Protection Association to attempt to formulate any standards.

In this same connection, Mr. Leonard C. Wason, of Boston, read a paper on "Concrete Building Construction," and Prof. Ira H. Woolson, of Columbia University, and Mr. Richard L. Humphrey, of the U. S. Geological Survey, described some of the fire tests on concrete that have been made in their respective laboratories. The members of the association seem to be favorably inclined toward concrete construction as a fireproof construction, but very evidently are desirous of much more information as to its behavior under actual conflagration. It is recognized that the laboratory fire test only approximates the conditions of a building under fire and there have been too few extensive fires in concrete structures for the insurance men to feel sure of their ground.

The report of the Committee on Hose contained several revisions of the present standard specifications for hose and hose installations. Most of the changes were merely to state the various requirements more clearly and in better English. The committee recommend that there be no restrictions on the lengths of unlined linen hose that might be installed for interior protection. The report and the new sp[illegible]cations were adopted with one amendment c[illegible]ng all reference to 2-in. linen hose to be on[illegible]d. The general opinion of the members [illegible] this matter seemed to be that the use of t[illegible]wo standard sizes, 1½ and 2½ ins., covers al[illegible]ds and that the sanction of 2-in. hose would[illegible]d to its use where only 2½-in. is large enoug[illegible]r where 1½-in. is required as being the large[illegible]hat could be handled, under pressure, by one [illegible]son.

The Committee on Hydrants a[illegible] Valves presented revised specifications of [illegible] and check valves for use on fire-protecti[illegible]lines. The changes over the old specificatio[illegible]ere largely for clearer expression and to a[illegible] minor advances in safe practice. New sp[illegible]ations were proposed for indicating valve post[illegible]r building-protection systems continuously und[illegible] water pressure. The revised specifications we[illegible] adopted by the meeting and the proposed new [illegible]pecifications were referred back to the committe[illegible] for revision and report to the executive com[illegible]ittee of the association.

The Committee on Fire Pumps [illegible]ade an informal report, the prominent feature of which was a recommendation that the excess capacity of rotary pumps, over their rating, should be reduced from 20% to 10%. It was stated that no centrifugal fire pumps had yet been built to conform to the association's standards. It was also recommended that with motor-driven pumps there should be a coupling, with some little flexibility between motor and pump. The whole report was adopted.

A committee reported on Private Fire Supplies From Public Mains. This committee made no specific recommendations, but brought before the meeting for discussion the need of preventing all possible "bleeding" of water-works in time of fire, by excessive industrial supplies or by broken sprinkler systems. It was a case of conflicting interests which, it was said, were coming to demand careful study to prevent serious trouble or occasional disaster. It was held necessary to provide ample water to make the inside sprinkler effective, but, on the other hand, should the sprinkler mains burst at a bad fire it was held to be very desirable to limit the water loss and to prevent crippling the adjacent sprinkler system and other fire-protection services. The committee advanced the opinion that no connection for sprinkler or industrial service, from street water mains, should exceed 4 ins. in diameter. The committee was continued for another year to formulate rules for private supplies from public mains.

The Committee on Standard Hose Couplings and Hydrant Fittings for Public Fire Service made a report of satisfactory progress in their work of having the association standards and specifications for hose and hydrant couplings adopted by the various interests involved, throughout the country.

The Committee on Artificial Refrigeration reported their investigations into the construction, operation and fire risks of plants of all types in common use in this country. The report gave a brief review of the history of mechanical refrigeration and stated the essential features of the several processes. The special fire hazards were stated to be few and easily cared for. The greatest hazard was held to be that of explosion and this was to be guarded against by so installing the compressing machinery that an explosion could not cause damage outside the room in which it occurred.

The Committee on Gravity Tanks (for fire supply) presented a set of specifications relating to location, size and construction. The committee's recommendations covered tanks of steel, wood or reinforced-concrete structures. Only one group of specifications were adopted—those for wooden tanks. So many adverse criticisms were made of the other groups for both tanks and supports that these sections were referred back to the committee for revision and presentation to the executive committee.

The Pipe Committee made an informal report, in which they recommended the adoption of the standards of the American Water Works Association for cast-iron water pipe. This caused

considerable debate, as the specifications for hydrants and valves, already adopted, demand proportions of bell ends to fit the pipe standards of the New England Water Works Association. The recommendation was referred to the executive committee, with power to take final action and this committee, at a later session, announced that the American Water Works Association specifications had been adopted with the exception that in the case of high-pressure, fire-service lines individual treatment would be permitted.

On the afternoon of the second day the members inspected the New York high-pressure water-supply system and visited the Gansevoort pumping station. The visit was preceded by a paper, read by Mr. A. G. Patton, of the New York Fire Insurance Exchange, in which the main features of the stations and piping system were explained.

At the final session Dr. Clarence Maris, Pyrologist and Assistant Fire Marshal of Ohio, presented a paper which was a memorandum of the success and failure, in the several American states and Canadian provinces, to create the office of state fire marshal. This official would investigate all fires of over $25 or $50 loss, ascertain the causes and prosecute cases of incendiarism.

The following officers were elected for the coming year:

President, C. A. Goddard, of Boston.

Vice-President, H. C. Henley, of St. Louis.

Secretary and Treasurer, F. H. Wentworth, of Boston.

The two first named being re-elected.

The Improved Drafting Machine.

Seven years ago we described in these columns a radical innovation in draftsman's tools, a device intended to eliminate the time-honored T-square and triangles. This was a parallel-motion linkage pivoted to a clamp fastened at one corner of the drawing-board and carrying at its free end a graduated revolvable head from which project two graduated ruling edges set at right angles. The chief purpose of the machine was to simplify and accelerate the tedious routine of drafting by substituting one motion for two or three; to enable one hand to do what formerly engaged both hands, and do it in less time.

Since then this tool, the "Universal Drafting Machine," has gone into use by the thousands, a satisfactory attest to the merit of the idea. Everybody who has done any drawing will appreciate, however, that such a device is essentially a precision tool, depending for even passable accuracy upon excellence in design and execution. Moreover, since it is more bulky, costlier and more specialized than the simpler tools it displaces, it needs to be made as adaptable and as handy as possible. On this account we are interested in some important changes and improvements which the makers of the Universal Drafting Machine have devised recently, as noticed below.

BALL-BEARING JOINTS.—There are eight main pivots or hinge joints in the linkage composing the machine; they may be recognized in the view Fig. 2 showing a recent form. These joints must meet two contradictory requirements: They must be absolutely tight, i. e., free from lost motion, and their friction must be exceedingly small.

The effect of looseness or lost motion in any one of the joints is greatly multiplied at the far end of the linkage, and vitiates the accuracy of parallelism of the ruling edge. An ordinary amount of looseness in all of the joints would make the angular lost motion or play of the ruling edge as large as that which so often proves annoying in an old T-square used on a drawing-board whose edge has pulled out of true.

The joint originally used on the "Universal" machine is a plain cone bearing. Since sliding surfaces will wear, looseness inevitably develops in time; therefore the cones (adjustable) are provided to give a means for setting the joint up tight again. The defect of this arrangement is that tightening up a plain bearing until no trace of play remains is apt to increase the friction of the bearing very markedly. In fact, sometimes a very minute change of adjustment is sufficient to change the condition of the bearing from looseness to binding. Even when not binding, however, the friction of plain bearings is large—very large in relation to delicate mechanisms.

The importance of low friction in the joints of this machine may be appreciated. The instrument is manipulated at its extreme outer end, and, the joints lying between this point and the anchorage, friction in them will tend to spring all the bars of the linkage. In other words, after moving the ruling edge there will be a certain elastic back-lash. If the friction were strictly zero, there would be absolutely no such back-lash, and in proportion as the joints approximate the frictionless condition the back-lash is reduced. Joint friction is not needed for making the instrument steady when set to a given position, because the ruling edge and the head-plate to which it is attached bear on the paper and produce sufficient friction to make the instrument as steady as the work requires.

The requirements of tightness and freedom from friction being essentially contradictory in the plain cone bearing, the interesting form of ball bearing shown by the adjoining drawing, Fig. 1, was designed. This is the exact equivalent of a double-cone bearing and is adjusted to tightness by setting up the upper cone, locked by a jam-nut. There is only a single row of balls, as will be seen, but by arranging the races to form a four-point bearing complete stability and steadiness is obtained.

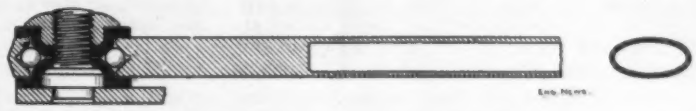


FIG. 1. SKETCH SHOWING TUBULAR ARMS OF ELLIPTICAL SECTION AND ADJUSTABLE BALL-BEARING JOINT.

(The ball-bearing joint shown can be adjusted so as to be absolutely free of lost motion, with very low friction.)

The effectiveness of this bearing may be judged from the following trial: A machine not attached to a board was completely extended so that the two sets of rods lay in a straight line; then, grasping the extreme ends of the assemblage, the machine was bent back and forth in a plane transverse to the plane of motion of the linkage. It behaved just as if it had been a continuous elastic body, that is, not the slightest slackness or knocking could be felt on reversing the bending. While there was this complete tightness, yet the joints rotated very freely.

In conjunction with this new joint construction, the makers are using tubular steel rods in place of the solid rods used in the older machines. These tubes have a flattened or elliptical section, with the longer diameter horizontal. The end portions of the rods, containing the joint, are solid. They are welded to the tubes by electric welding. The upper rods—that is, those nearest the fastening or anchor—are swaged to a tapered profile largest near the anchor, where the bending effect is maximum. The ball joints at the anchor, moreover, are larger than the others.

The combination of hollow rods with maximum stiffness in the horizontal plane and adjustable ball bearings seems to meet the requirements of strength, stiffness, lightness and freedom from both lost motion and elastic back-lash almost ideally, in so far at least as the design can do this. The workmanship seems to be adequate to carry out these effects in practice.

ANCHOR AT MID-LENGTH OF BOARD.—The original machines were attached to the board, or "anchored," at the upper left-hand corner of the drawing-board. The action of the linkage, of course, is independent of the location of the anchorage; but with a given machine, the normal setting of the protractor head to which the ruling edges are attached fixes the proper location of anchor. While the corner location has its advantages, it has the disadvantage that for work on the left-hand half of the board the rods project out to the left. When working near the upper left-hand corner, the projection may amount to the full length of a single pair of rods, say for the ordinary machine

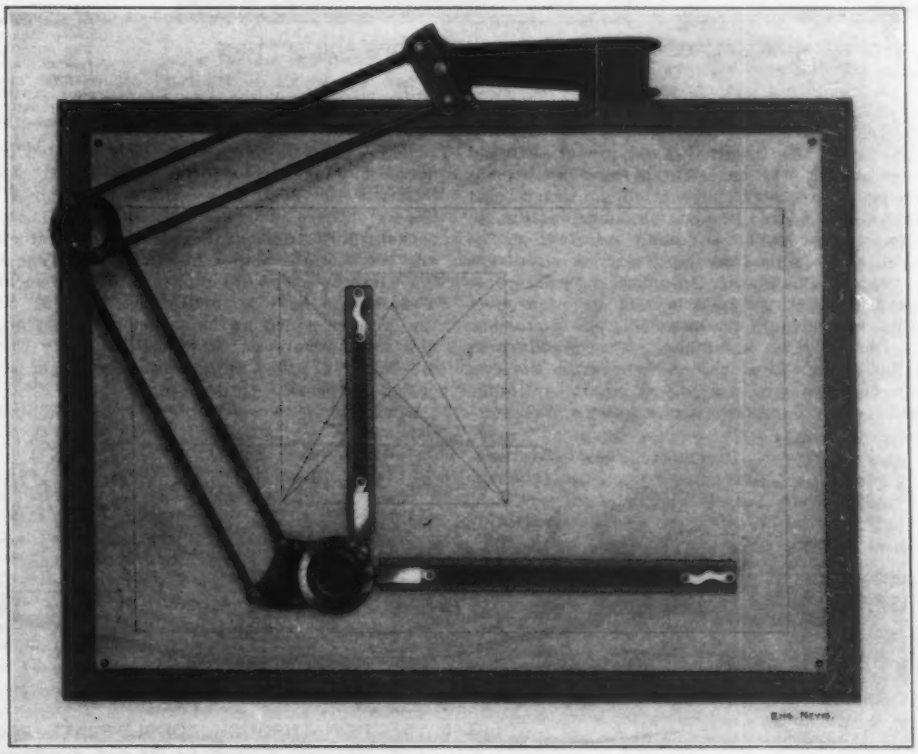


FIG. 2. DRAFTING-MACHINE WITH ANCHORAGE AT MID-LENGTH OF BOARD.

(This new arrangement greatly reduces the "elbow-room" needed at the left of the board in the original corner-anchor form of the machine. It requires clearance beyond the top of the board, however, when the machine works close to the upper left-hand corner of the board; when this clearance is not easily provided, but side clearance can be had, the corner-anchor type is the appropriate thing to use.)

some 25 ins. The inconvenience of this is obvious, especially where quarters in a drafting-room are so close that drawing-boards cannot readily be spaced so far apart as to give so much "elbow room." The mid-anchor arrangement, developed not long ago, avoids this disadvantage very effectively.

The view Fig. 2 shows one of these mid-anchor machines, in which the clamp or pivot is fastened to the drawing-board at about mid-length of the upper edge. In this form the rods never project beyond the left-hand edge of the board, and, of course, never beyond the right-hand edge. For a vast majority of movements over the board, therefore, the arms do not project beyond the board at all; they do so only for work in the upper left-hand quarter of the board, and in this case the projection is upward or beyond the board. In most cases there is plenty of room available in this direction.

The mid-anchor arrangement has a further but less obvious advantage. The effectiveness of the linkage is at a maximum when the two rods of each arm are widest apart; in other words, when their four pivots form a true rect-

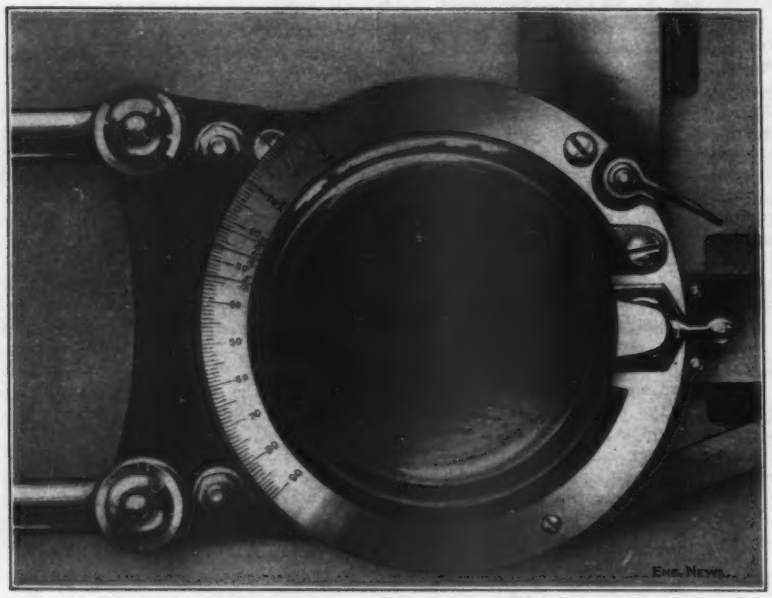


FIG. 3. SINGLE-PLATE PROTRACTOR, WITH STOPS FOR SETTING TO STANDARD SLOPES.

angle. This will occur in only one position on a board, and in all other positions of the instrument the rods will be nearer together and therefore in a less effective relation to each other. The average departure from the ideal condition will depend on the angle of displacement of the two pairs of pivots in the connecting ring between the two arms. This angle is not arbitrary, but is governed by the requirements of reaching the different corners of the board. Now, it happens that with the mid-anchor style the angle between the two sets of pivots is more favorable to maintaining the best efficiency of the linkage throughout the most-used portion of the drawing-board than with the corner-anchor style. The mid-anchor type, therefore, has slightly higher inherent accuracy than the other.

DOUBLE-PLATE PROTRACTOR.—The working head of the machine to which the ruling edges or scales are attached is represented very clearly in the photograph Fig. 3. It comprises a graduated plate adapted to rotate in the main terminal or frame plate, carried at the end of the linkage rods. A knob on top of the graduated plate enables it to be turned and gives a means for manipulating, lifting and shifting the machine. At the bottom of the graduated plate there is a small foot or shoe of metal, which supports the head a short distance above the paper. There are also attached two metal sockets projecting out beyond the circumference and set at right angles to each other. The ruling edges or scales are slipped into these sockets. The sockets have a small taper, so that when the scale is seated in the socket it is held firmly and rigidly, but can be taken out easily and a differently graduated or shorter or longer scale put in its place.

Incidentally, the metal tenons on the scales, which engage these sockets, are adjustable, being fastened by two screws, of which one engages a transversely slotted hole. By this means all the scales of a set can be adjusted to exactly identical setting, so that all scales, when placed in a given socket, will match the same line. The two sockets attached to the graduated plate must of course be themselves at right angles, and to obtain this adjustment one of the two sockets is pivoted in the plate and can be swung laterally for adjustment by a screw.

This form of head has proved completely satisfactory for all ordinary purposes. In such work, however, as mapping, where slight variations in the meridian of reference occur from time to time or where angles are set [illegible] reference lines—as in travers[illegible] backsights and foresights giv[illegible] angles of a network—the sing[illegible] is rather awkward, and it is de[illegible] two-plate head such as is provid[illegible]

Such a head has been brough[illegible] the "Civil Engineer's" protracto[illegible] Fig. 4 and shown as to cons[illegible] sectional drawing Fig. 5. Its c[illegible] ing fully shown, requires no fur[illegible] except for the remark that th[illegible] not seated centrally but is engaged for about 90° of its circumference by a dovetailed rabbet in the frame plate, to which it is held by a retaining plate with clamp screws. The head, therefore, consists of a frame segment and outer plate which can be clamped in the frame segment, and an inner plate which can be clamped in the frame plate. All these parts are stamped out of German-silver plate.

This head differs from that of the surveying instrument in the further point that it has no slow-motion screws. It should be considered, however, that a draftsman makes a setting by taking hold of the extreme edge of one of the scales, so that he has a lever arm of perhaps 24 or 30 ins. He can in this way make a very fine setting without need for a setting screw. The graduation of the head shown in Fig. 4 is to half-degrees, and the vernier on the inner plate reads to single minutes.

SPECIAL FORMS OF MACHINE.—A number of special forms of the "Universal" drafting machine have been produced, for particular uses, which it may be interesting to mention. The simplest is a modification for working on a vertical board. This is an ordinary machine with long spiral tension springs inserted in the two parallelograms of the linkage, to counterbalance

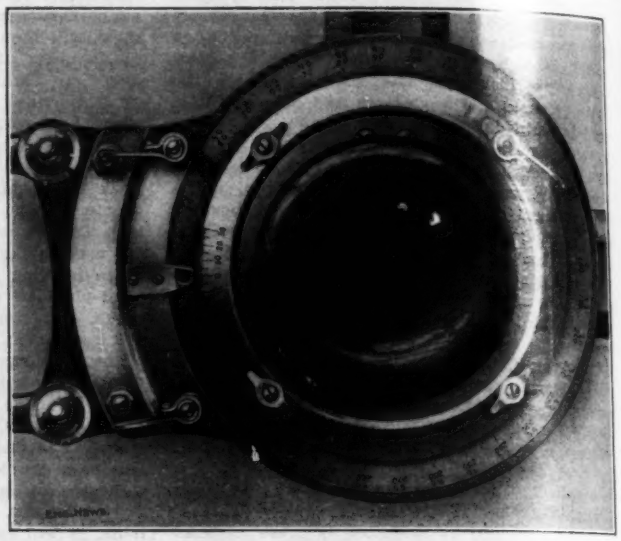


FIG. 4. DOUBLE-PLATE OR CIVIL ENGINEER'S PROTRACTOR.

(The inner plate, to which the knob and the scale-holders are attached, is held in the outer ring by four retaining lugs below; three of these lugs are held by screws with spring washers bearing on the upper surface of the plate, which may be tightened to increase the friction of turning, while the fourth carries the clamp screw for clamping the inner plate. The outer plate, which bears the graduation, is set in a rabbet of the frame plate, at the left of the picture, and is clamped by two clamp screws which engage a retaining ring below. The motion of the outer plate can be read to half degrees by a gage point attached to the frame. The inner plate has a vernier reading to minutes on the graduation of the outer plate.)

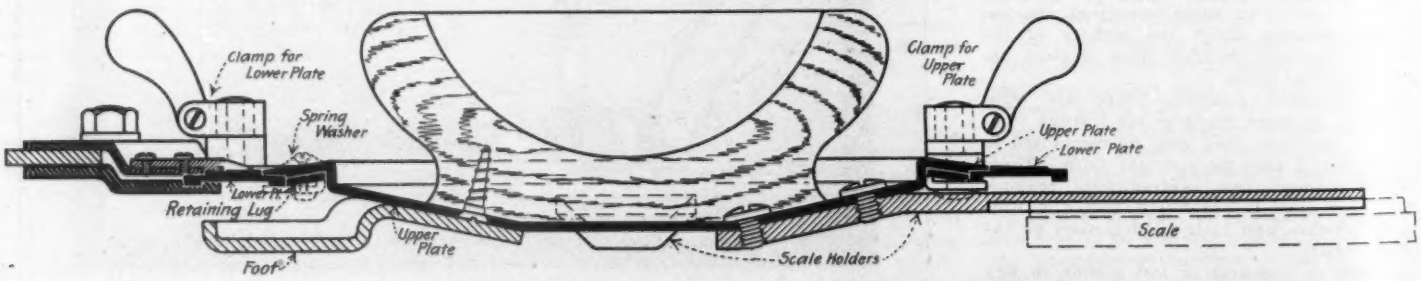


FIG. 5. SECTION THROUGH DOUBLE-PLATE PROTRACTOR.

(The inner plate is dished for the sake of stiffness.)

the weight in any position as nearly as may be. Another is a modification for very, long boards, where it is not feasible to make the arms long enough to stretch the full length of the board. In this case the anchor or fastening of the linkage is held by a light carriage adapted to travel along a rail screwed to the top edge of the board. The arms of the machine in this case are proportioned to suit the front-to-rear height of the board, and the longitudinal motion is taken care of by the carriage. Exactly the same purpose is served by another machine, in which no rails fastened to the board are required; the anchor in this case is set on a heavy shaft running over the board front to rear, the shaft bearing a small wheel at each end which can roll along the board over the drawing. This is in effect a parallel ruler of the roller type, carrying a parallel ruler of the link type.

A special make of the traveling-carriage machine has been produced for working on school blackboards. In this case the rail is set horizontally along the top of the blackboard, and the machine hanging from it is provided with a spring counterbalance as already mentioned. The rulers of this machine are thick, suitable for working with blackboard crayons. The general construction of the machine is specially adapted to the particular purpose.

Several other modifications and improvements of this machine might be mentioned, among them, in particular, a white-surface metal scale which is said to be fully as readable as a celluloid-edge scale; and thumb-tacks turned out of solid metal, with perfectly sharp edge of the head so that the scales of the drafting machine will slip over it without catching and without being injured. These thumb-tacks, of course, cannot be pulled with the fingers and would be injured by pulling with a knife. A hook lifter is used with them, working in two holes punched in the head of the tack.

These various minor improvements and auxiliaries are not fundamental to the utility and value of the machine. Those first described may properly be called fundamental, however, in their relation to the essential points of accuracy and convenience.

Principles of Sewage Purification on Land.

(*Continued from Engineering News, May 27, 1909, p 586.*)

By RUDOLPH HERING,* M. Am. Soc. C. E.

Summary.

In the endeavor to summarize the conclusions already stated, gained chiefly from the inspection of European sewage purification works, as regards the fundamental principles which seemed to underlie their actions and resulting effluents, a fact became evident that had not before been appreciated. It seemed, after grouping the data, that the factors of bacterial surface, air supply, and time necessary for oxidation varied directly with the number of persons whose sewage was considered.

This suggested going back to one of the amusements of college days, in the application of mathematics to the ordinary pursuits of life, and putting into the form of an equation the relationship of the various facts concerned in the business of sewage purification. Though it seemed odd to put a biological process into a mathematical frame, yet, seriously speaking, an algebraic expression often helps to clear the mental conception in more or less involved questions.

After a number of trials, the expression given below was found to cover the case and to assist in a better understanding of the interrelations.

Bacteria operating in the bacterial film spread over the surface of the grains, where they vary in quantity per square foot from zero to a degree of complete ripeness of the film. At the stage of complete ripeness, let us assume, as was done near the beginning of this discussion, that the daily sewage of one person will require a bacterial surface of b sq. ft. upon which to oxidize the sewage and produce a degree of purification which we may call p.

For the work of purification, the bacteria must have a sufficient amount of air to oxidize the liquid organic matter. This has been determined by several authors, but not with reference to all of the usual variants.

Let us assume that the quantity of air which is supplied to oxidize the sewage of one person to the degree of purity p is a cu. ft. per day.

Purification requires a sufficient time for the sewage to be in contact with the bacterial film, which is the time required to percolate through the filter medium, and let us further assume that the length of time necessary for oxidation to the degree of purity p is t minutes.

It was not difficult to reason out that the relation between these factors is

$$p = bat.$$

Let us see from an example what this means, by using the only data just now convenient and given in the early part of this discussion.

The numerical values for b have already been given. The numerical values of a and t have been estimated from the data given by Rideal and Clifford. Even if they were materially in error, they show all that is here desired, by illustrating the application of the formula.

City.	b Bacterial surface per person, sq. ft.	a Rate of air supply per person, cu. ft. per day.	t Time of purification, mins.	p Relative degree of purification.	Character of effluent.
Hanley	710	4	76	216,000	Excellent.
Birmingham ...	367	5	40	73,400	Fair.
Wilmersdorf ...	160	7	15	16,800	Tolerable.

From any three of these factors the fourth can be found.

There are, of course, certain limits to the values of the factors in this formula, as in most others, beyond which it will not apply. These limits are due to the fact that the organic process of purification depends on a least air supply. The bacteria must also have a certain minimum time to do their work. In cold weather they are less active and may diminish in number, which establishes a further minimum condition. The maximum limit of air supply will be that which supports the greatest intensity of bacterial action, beyond which no further supply is needed. Nevertheless, more air than necessary apparently does no harm, and since more failures of sewage purification works are attributed to an insufficient than to a superfluous air supply, the maximum limit is of no moment.

Therefore, the factors b and a hold within certain limits a relation towards each other which is different from the relation which either holds to the other factors.

The only factors, having a fundamental relation to sewage purification and which are not embodied in the formula, are liquidity and temperature.

It is assumed here that the sewage has been rendered as nearly liquid as is practicable by means of a preparatory treatment. Regarding temperature, the data are not yet available to determine its exact relation to the other factors. The factor p, in representing the degree of purity, really means the amount of nitrification and other changes brought about by bacteria.

The factor of time is chiefly applied to the percolation, although, while the sewage is exposed to the air as a fine spray, a portion of the required air is then already taken up. We must also realize that as time goes on and the air is being supplied to the same ripe bacterial surface, the purification becomes continually greater, until it is complete.

If plenty of air is available, putrescence quickly ceases. Therefore, with a good air supply we may expect sewage to become non-putrescent in minutes to be followed by oxidation which may not be completed in hours.

Let us now make an analysis of the indication of the formula with the above illustrations before our eyes. Let us assume that any two factors are constants and inquire into the relation of the others. There are six possible cases.

Case 1; b and a constant: The purification varies with the time. The longer the bacteria act the greater will be the degree of purification.

Case 2; b and t constant: If the bacterial surface is ripe, a further access of air would be of no use. We would go beyond the limit due to the organic fixed relation between b and a, below which a greater air supply (a) permits of a smaller bacterial surface (b), on account of there being a larger number of bacteria per square foot due to the greater ripeness.

If the bacterial surface has not reached complete ripeness, then an increase of air will induce it to become riper, and in so doing will correspondingly increase the degree of nitrification or purification.

On the other hand, whether the bacterial surface is ripe or not, a decrease of air supply will correspondingly reduce the degree of nitrification.

Case 3; b and p constant: If a smaller quantity of air is supplied, it will take more time to effect the purification. This may be accomplished either by the bacteria working slower, which they do under favorable conditions, or only a part of the number of bacteria of the ripe surface may be present. In other words, the surface may not be ripe. If double the quantity of air is supplied, then in a ripe bed we may have gone beyond the limit, and in an unripe bed the surface may be made more ripe and the time for oxidation correspondingly shortened.

Case 4; a and t constant: The purification will vary with the area of the bacterial surface b, and it will also vary with the degree of its ripeness; i. e., twice the number of bacteria will produce twice the purification. We have in this case an illustration of the sand filters.

Case 5; a and p constant: If the air supply is greater than the normal amount producing the best purification in the bacterial surface, then we have once more gone beyond the limit and the purification will become no greater. If the air is less than this amount, then, to maintain the same degree of purity, it will take twice as long to produce this purification; if only one-half the bacterial surface is available, or the whole surface is but half ripe.

Case 6; t and p constant: The larger the bacterial surface the less need be the air supply down to the limit, when the air must be sufficient to maintain bacterial oxidation, which will produce the nitrification required by p. The smaller the bacterial surface, the larger must be the air supply, up to the limit beyond which no further purification takes place. If the filter is unripe this limit is correspondingly distanced.

The formula indicates the further conclusion that the weaker the sewage the less need be the figure under degree of purification, and, consequently, the lower would be the value of b to obtain the same degree of purity as required by a stronger sewage.

It is necessary to state here with some emphasis that the suggestion of a formula should not be misunderstood. It is but a skeleton from which to recognize general relations. It assists the grasping of interacting elements and the drawing of logical conclusions, and points out easily what is otherwise hardly recognized.

Although much more information is yet required, we have, it seems, sufficient data, as herein given, to test at least the rationale of the proposition.

An analysis of the sort here outlined, although by no means without many imperfections and perhaps even faults, appears to the writer to lend itself towards the working out of a method which tends to unite discordant opinions, and gives a practical guide towards designing works along more scientific lines than heretofore.

If the above conclusions, drawn from personal observations in both our country and Europe, but roughly approximate the principles that in the future should guide us in the construction of these important sanitary works, then the directions in which additional data are needed, so that filters may do their maximum work at the minimum expense, are somewhat more definitely indicated than heretofore.

They may be stated as follows:

Physical Data.—The *surface* upon which a bacterial film can adhere, not only of a single grain of the various materials that can be used, but also in square feet per cubic foot, of a mass of grains, more or less compacted, when they rest upon each other and therefore when the free surface per grain will become less.

*Consulting Sanitary and Hydraulic Engineer, 170 Broadway, New York City.

The length of *time* required for sewage of different degrees of temperature and foulness to percolate 1 ft. in depth through filters with grains of sizes varying from ⅛ to 3 ins. diameter.

Biological Data.—The ripe *bacterial surface* in square feet, the quantity of *air* in cubic feet per day and the length of *time* required for the continuous oxidation of the putrescible sewage matter of the average person, under different temperatures and to different degrees of purity.

This concludes the discussion of the main treatment of sewage. It remains now to discuss similarly the chief factors which are concerned in the preparatory treatment of sewage, preceding oxidation, and in the after treatment, following oxidation.

Construction of Streets and Sewers in Saturated, Newly-Filled Land, Wildwood Crest, N. J.

Near the southern end of the Atlantic Ocean coast of New Jersey, there is an island, separated from the shore by a narrow channel, known as Five Mile Beach, on which is situated the city of Holly Beach. Some three years ago the growth of the town required its extension to the south, over a part of the island composed, as is most of the Jersey coast, of mud and sea sand, but which at high tide was three feet under water. The reclamation of this land, now known as Wildwood Crest, covering an area 7,950 ft. long and from 680 to 3,470 ft. wide, and the building thereon of a city street and sewer system is the subject of a paper before the Canadian Society of Civil Engineers, by Mr. Geo. L. Watson, who had charge of the work. From that paper we have abstracted the portions which relate to the peculiar street construction and to the methods of laying the sewers.

Examination of the ground showed it to consist of a thick black mud covered with heavy meadow sod, some rank growth and irregular mounds of sand, which latter, owing to the currents, were constantly changing position. It was decided that a satisfactory surface could be obtained by pumping on the ground sand from the ocean to a depth of four feet, thus bringing the level to one foot above high tide. This filling was made with hydraulic dredges, pumping from the ocean bottom behind a light fence-like bulkhead that was driven around the confines of the desired reclamation area. After the requisite amount of filling had been made it was found that the currents outside the bulkhead were so strong that some measures would have to be taken to protect the filling, so an extra bulkhead or breakwater was constructed some 35 ft. farther seaward. This consisted of a double row of piling protected by a brush mattress and further guarded by crib jetties extending from the shore. This construction caused the formation of a gradually sloping beach, at the water line of which was built a boardwalk along the whole length of the new land.

The work then proceeded to the construction of the streets and sewers, of which there were over ten miles to be built. The accompanying cut shows the type of section used on the two main streets and will serve to illustrate the entire work. It was thought desirable to place the sewers under each sidewalk rather than one large main under the middle of the street where the railway line would interfere with future changes or repairs. Similarly, the public service conduits were placed in a strip 8 ft. wide reserved for this purpose between the sidewalk and the property line.

The main sewers, on either side of the street, were 18-in. terra cotta pipe, and as the trench for the entire distance, some 16 miles, was through quicksand, known locally as "boiling sand," the excavation was both expensive and difficult work. It proved so difficult to keep the pipes to grade and alinement that a cradle was designed on which they could rest. This cradle, with the methods of excavation finally devised, proved very successful. The cradle on which the pipe rests consists of a double row of piles, 7 ft. apart, crossed on top with 4 × 6-in. timbers which in turn carry 2 × 8-in. hemlock planks on which the pipe is laid. The upper part of the cradle, without the piles, is shown on the cut.

In the excavating great trouble was experienced in keeping the trench dry, though a double-row of sheeting was employed. Sumps or wells could not be made as the pumps pulled out so much sand under the sheeting as to cause either the ditch to fill or the sheeting to cave in. Water in great quantity was struck 12 ins. below the sand grade. Finally, however, headway was made in the following manner, as described by Mr. Watson in the paper:

By using a piston pump the sheeting was put down for a distance of 150 ft. along the trench, and closure made at each end. Then ten laborers were put in the trench and excavation made to the water line, when rangers and braces were set. A piston pump was then started pumping water into this "land cofferdam." A centrifugal pump was moved in position, and the discharge pipe placed midway in the last section where the sewer pipe had already been laid. Thus the centrifugal pump excavated the material from the forward section and backfilled the last section at the same time.

When grade was reached the foundation piles were jetted down and the cradle constructed. The pipe was then laid, the joints being made with neat cement and boiling tar, as this was found, after experiments, to be superior to sulphur, cement, asphalt, or sulphur and sand. The next section was then done in a similar manner.

The sand excavated was quite coarse, and but little agitation was necessary with shovels, in order to allow the pump to pick up the sand. When the sand is fine grained much more water is needed, and likewise it must be agitated with shovels. With extremely fine sand the men must be relieved frequently, as the work is hard, and the pump taking up a much smaller percentage of the sand, means the ditch must be kept with a larger amount of water in it, and the men, being compelled to stand in the water, feel the effect of it quickly.

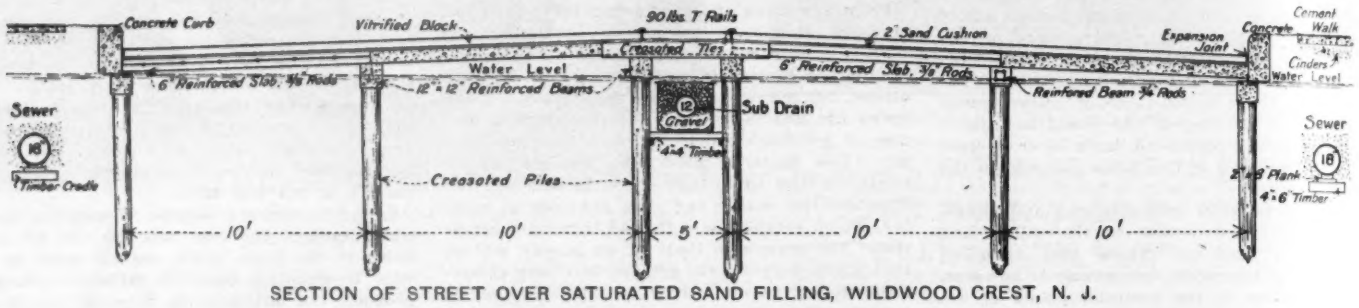
Under this system of construction 300 lin. ft. of trench was dug and pipe laid, per day, while on similar work under the same conditions in Holly Beach a contractor made but from 35 to 50 ft. per day, doing the work by another method.

At intervals manholes were placed. When these came in "salt holes" or soft places, four piles, 10 to 15 ft. long, were driven about 4½ ft. c. to c. and on their heads was bolted a square of four old railway ties. Upon this as a foundation a box 5 ft. square and 10 ins. deep was placed and filled with concrete as the bottom of the manhole, the sides of which were built of brick.

In all but the two main thoroughfares the water and gas mains are in the middle of the street; in those two streets they are on the sides as shown. Very little trouble was experienced in laying them in either case. The sidewalks were concrete 3 ft. wide, and were placed as soon as the conduits were laid. Then a 9-in. layer of gravel was put down on the s and upon that the pavement was

The street itself is practicall posed of a reinforced-concrete s piles. As shown in the sectio panying cut, creosoted piles abou driven at the curb line, halfway and under the tracks. These pil ft. c. to c. across the street, exce the rails, which were 5 ft. apar c. along the street. Cast in of the piles are 12 × 12-in. re beams running the 6 ft. b piles in the line of the s piles a 6-in. concrete slab reinforced with ⅝-in. steel and wired. These slabs were c 10 × 6 ft. in plan and when set w their corners over the piles. Th under the rails was finished in a s the ties resting directly upon the slabs being notched for the ties.

On top of the slabs there was la sand cushion for vitrified block pa Expansion joints were placed along the curb alternating every 200 ft. At frequent intervals drains were laid under the middle of the street connecting with the nearest sewer manhole. These drains were composed of 12-in. terra cotta pipe laid with burlap joints with gravel casing in a box crib resting upon stringers spiked to the two middle rows of piling every 6 ft.



SECTION OF STREET OVER SATURATED SAND FILLING, WILDWOOD CREST, N. J.

After the completion of this street it was decided to extend it about 1,000 ft. When the necessary excavation was made it was found that the sand had receded 18 ins. from its original level against the bottom of the roadway slab and that water was flowing 6 ins. deep under the principal streets of the town.

THE POLLUTION OF THE OHIO RIVER, and particularly methods for its prevention, were discussed at a meeting of the Ohio River Sanitary Commission held on May 18 at Wheeling, W. Va. The Commission is composed of representatives of West Virginia, Ohio, Pennsylvania and Kentucky, appointed by the governors of the states named. Dr. C. O. Probst, of Columbus, Ohio, was chosen as secretary of the Commission. The following resolutions were adopted:

Resolved, That the interests of the public health may not be sufficiently safeguarded by the installation and operation of a water filtration plant when the source of supply is a highly sewage polluted water, or is liable to serious pathogenic pollution; for the particular reason that a filter plant may be overtaxed or may break down or may be put out of commission temporarily, with the consequence that sewage poisoned water may be accidentally or negligently introduced into the water mains and hence into the homes of water consumers and produce disease and possibly death. The concerns of public health demand that sewage pollution of the source of water supplies shall be kept down to a practicable minimum in the first place.

Resolved, That we recommend to our respective legislatures the enactment at their next sessions of such a law as may be necessary to prevent the introduction of any additional sewage into the Ohio River or into any of its tributaries, which affect the public water supply of any municipality; and

Resolved, Further, that we respectfully ask the governors of our respective states to embody this recommendation in their messages to the legislatures.

It was decided to request the boards of health of the four states represented to supply the Commission with typhoid-fever statistics for towns on the Ohio River within their several jurisdictions, and also give the populations of the municipalities using the Ohio River as a source of water-supply and as a means of sewage disposal. Secretary Probst, it is stated, was authorized to engage an engineer to make an investigation and report on the pollution of the Ohio River from Cincinnati to its headwaters. The proposition was made to draft a uniform law governing the pollution of the Ohio, for submission to the several legislatures.

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Appropriations for river improvement and flood prevention made by the recent New York Legislature have been vetoed by Governor Hughes, partly on the ground of the need for economy, but also on the ground that the localities benefited should share in the cost of such works. The Governor says, in his veto statement:

> The number of requests for appropriations for river improvements in various parts of the state and for protection from loss by floods calls attention to the necessity for providing a proper system by which the needs of these communities can be met in a just way.
>
> Under the present system, legislative acts or items in appropriation bills are sought which place the entire cost of the improvement upon the state. But it is apparent that in view of the limits of the state's income and the pressure upon it, a proper distribution of the expense of such improvements should be made so that the cities, towns and counties directly benefited may bear what may be found to be their proper share.

We are far from questioning Governor Hughes' good faith and good intentions; but it has been amply demonstrated by actual trial in the State of New York that the attempt to create reservoirs which will furnish flood protection and benefit water-power cannot be accomplished by distributing the cost upon the parties benefited. In theory, such a distribution of cost would seem to be ideal; in practice, it is impossible to work out in a way that will permit of proper financing. This fact was well set forth in the annual report of the State Water Supply Commission.

While the condition of the state treasury may perhaps have made the veto of the appropriations necessary, it ought to be clearly understood that the only way for real, comprehensive work in river improvement to be undertaken is by direct appropriation from the state or national treasury. While it is true that such appropriations operate for the benefit of special localities, the same thing applies to many other appropriations of the public funds. Furthermore, with a proper policy of state control of water-power development, it should be possible to pay a large part of the cost of river improvement in New York from the sale of the water-power created.

We are obliged also to criticize another act of Governor Hughes, in approving an appropriation of $25,000 for the expenses of the New York commissioners who are working with commissioners from New Jersey in the investigation of the project for constructing a bridge over the Hudson River at New York City. Here again there is no need to question the good faith of the Governor or of the Legislature in passing this appropriation. But the fact is that the whole agitation for this proposed bridge is being carried on merely to further the schemes of real estate speculators interested in the development of tracts of land in New Jersey.

Space does not permit here a complete review of all the facts regarding this enterprise. The situation, in brief, is simply that a bridge across the North River would cost so vast a sum of money that private capital cannot possibly be enlisted to undertake its construction as a commercial enterprise. While such a bridge would benefit certain tracts in New Jersey, its cost is far too great to permit of its construction on the basis of the land values it would create.

It may be thought that there is a possibility of the bridge being constructed by joint contributions from the treasuries of these two States; but even a cursory examination of the State constitutions, and of the limitations there set to the appropriation of public funds and the creation of debts makes it clear that such appropriations are too remote to be worth serious consideration. Even if these constitutional objections did not exist, it is evident that neither State would use State funds for a work benefiting a locality covering only a few square miles of area.

The real reason why the bridge project is kept before the public is for the benefit of sundry speculators in real estate. Farms and waste lands have been cut up into city lots and are being sold to credulous purchasers on the strength of the assurance that a joint State commission is working on plans for a bridge across the Hudson which will make the lots as valuable as real estate in Manhattan. The public naturally supposes that the State governments of New York and New Jersey really intend to build a bridge across the river, and so the sale of lots goes merrily on. It is a pity that the funds and the authority of the State should be made use of to deceive the public and benefit speculators in real estate.

With all that the National government and State governments may do in the way of establishing public forest reservations, it is clearly recognized by all who have given careful study to the matter that forest preservation and forest cultivation can never reach the scale necessary to supply the demand for forest products until the work is taken hold of by private enterprise. Thousands upon thousands of landowners must undertake the cultivation of timber in order to place us beyond the danger of perpetual timber famine.

It has recently been pointed out, however, that the necessary first step in interesting private landowners in timber cultivation and in the preservation of existing forests is the prevention of forest fires. It cannot be expected that a private owner of timber lands will preserve them uncut, if at any time a forest fire may wipe out his property entirely.

In a recent number of the "New England Magazine" this fact is brought forward in a forcible manner, in a contribution by "An Old Farmer." Farmers are often criticized for selling to lumbermen and to pulp mills the right to strip bare the wood lots on the farms. "An Old Farmer," however, declares that many farmers would be glad to preserve the timber tracts on their farms as a safe form of savings bank. They fully appreciate the rapid increase which is taking place in the value of timber lands. It is not so much the wish to realize ready money from the sale of their lands that leads them to part with them, as the fear that their forests will be destroyed by the recklessness of hunters or campers. He states that after seeing many losses in his neighborhood from this cause, he parted, much against his wishes, with a valuable tract of pine timber on his own farm. As a remedy for this condition, he suggests not only more stringent measures for forest fire prevention, but a system of state insurance for forest lands. The idea is certainly worth consideration if such insurance cannot be supplied by private enterprise.

It is probable that the first work on a large scale in timber cultivation in the United States will be done by the railway companies. Indeed, a considerable number of the larger companies have already embarked in this work, and the absolute necessity of providing ties for use a few years hence is being realized by the managers of most of the railways. A circular letter to the railways of the country on this subject is being sent out by the Government Forest Service, and the replies received indicate deep interest in the matter on the part of railway officers.

A new forest reservation has been created in the state of New York, located in the Hudson Highlands on the west side of the Hudson River, extending from Stony Point to Cornwall. The area of the reservation is about 75 sq. miles, excluding lands cultivated and suitable for residential purposes. A notable feature of this forest reservation is that it is not proposed to acquire the forest within this area for state ownership, as in the Adirondack Park. Instead, the Forest, Fish and Game Commission is given power to supervise and control the cutting of timber upon lands within the reservation, "both public lands and such private lands as are suitable for the growth of timber only." This application of the police power of the state to prevent the cutting of growing timber on private lands is a new departure in the state of New York, and a most important one.

The Construction of Rapid Transit Passenger Subways—Reducing the Cost and Increasing the Earning Power.

Subways for city passenger traffic are engaging attention in fully half a dozen cities. New York, Boston and Philadelphia all have projects in hand for adding to their mileage of subsurface roads; and subway projects are being actively canvassed in Chicago, Cleveland and Pittsburg.

The advantages of subway transit are pretty well understood; but the difficulty with past subway construction is that the first cost has been so great that the traffic pays only a moderate return on the investment. This is true even of the densely crowded New York and Boston subways now in operation; and it ought to be clearly understood that the conditions in those cities are exceptional and are no guide to the results which may be expected everywhere.

This is well illustrated by the experience nearly 20 years ago in the construction of elevated railways. The elevated railways of Manhattan, where traffic is restricted in direction by the rivers on each side of the island, became very profitable. The elevated lines of Chicago and Brooklyn, where traffic radiates from over a center, failed of financial success.

The great difficulty in subway construction is to build a subway which can pay a profit. There is plenty of demand for subways for the convenience of the traveling public and for the benefit of real estate owners; but this demand is not accompanied by a willingness to pay the cost.

Subways ought to be so built as to pay a profit, even though they may be built with public funds. The money collected from taxpayers ought to be used in enterprises which will pay. Claims that the indirect benefits will justify the use of public funds in losing enterprises should be scrutinized with great care.

It is, therefore, a question well worth discussion how the cost of subway construction may be reduced. If this cost could be materially cut down, the rapid transit problem of a dozen cities would be promptly and effectively solved. Private capital would be eager to build more subways and the cities themselves could undertake such work without endangering their financial solvency.

The main reason for the high cost of subway construction is not the cost of the material in the subway structure itself—the concrete and

steel in the walls and floor and roof; it is the expensive manner in which the work is done. If it were possible to take a city street a mile or ten miles in length, entirely close it to traffic, attack the whole work as one big enterprise, excavate with steam shovels, carry off the material in trainloads, install huge mixers for placing concrete, special forms capable of repeated use and cranes for handling and setting them; —if subways could be built in such a way, then the cost of subway construction could be very greatly reduced.

Admittedly such radical measures are not possible of adoption; and yet is it not possible that some approach to them might be made? The tendency nowadays, however, is in the contrary direction. There is insistence that the street shall not be closed at all while construction work is going on, no matter what the added cost involved. In some of the subway work in New York City the entire street surface has been planked over and the subway construction has gone on beneath while the traffic continued overhead. There are locations where such extravagance is necessary; but to insist on such expensive methods being adopted everywhere is against the public interest. If subways are demanded for public convenience, then the public and the adjacent property-owners ought to be willing to submit to some temporary inconvenience while construction is going on. Some streets might even be closed to traffic temporarily. While this may seem a radical proposition at first sight, it is a fact that if the street can be turned entirely over to the workers so that the task can be handled in a systematic way, the work can be completed in a fraction of the time required if it is necessary to work piecemeal and be subject to obstruction by the regular traffic.

Again, there ought to be possibilities in the application of the well known sewer-trench machines to subway construction. Some of the large flood-water sewers now being constructed do in fact approach railway tunnels in size. We refer, of course, to the well known traveling trestle carrying a track on which the buckets carrying material excavated from the heading run back and are dumped over the roof of the completed tunnel. This system has the further advantage of disturbing only a very short section of the street at a time. It should be feasible to combine with such an overhead trestle a carrying system for transporting the concrete and other material required in building the tunnel.

There is another direction in which subway construction cost could be reduced, and that is by reducing the size of the cars and the cross-section of the tunnel. This may seem like a retrograde step; but is it not better to plan something which can be built and made practicable and profitable, rather than something which cannot be built at all except at some one's loss? Smaller cars need not necessarily be less comfortable or have less air space per passenger. The first city underground subway in the world, built at Buda Pesth, Hungary, 14 years ago, is only 9 ft. high above the rail and 9½ ft. wide. This double-track subway cost only about $650,000 per mile. The car floor is dropped between the trucks, so that ample head room is given in the passenger compartments. There is no difficulty in building and operating such cars, and in fact they have some advantages when used as surface cars in being easy to step into and out of. The difference in cost of construction between an underground railway with 9 or 10 ft. height and breadth and one 12 to 13 ft. in dimensions will be appreciated by any engineer.

Of course we are by no means advocating here such small size subways for cities like New York or Chicago, where traffic is quite certain to reach the limit that can be accommodated in a subway large enough for the standard passenger cars of city railways. We mention it as merely one possible solution of the rapid transit problem in smaller cities, where first cost of construction must be kept very low if the work is to be done at all.

The question of the relative merits of two-track and four-track subways appears in somewhat different light, since experience was gained in the operation of the New York subway. It has become clear that the proper function of a subway is to care for long distance traffic—people who are going at least a mile or two—rather than the short distance riders. If a man wishes to go only half a mile, it is not worth while to go to a station, descend the stairs, wait for a train and then climb the stairs at the other end. He can reach his destination as soon or sooner and with less exertion by taking a surface car—as ordinary street cars have come to be known in New York City.

The idea of the four-track subway is that passengers will take the subway at the local station nearest them, ride to an express station, change to an express train to the station nearest their destination, and perhaps to a local train again to finish their journey. This is actually done in many cases; but if it were possible by paying a single fare for the whole journey to use the surface cars instead of the local subway trains to go to and from the express stations, the public would be in many cases even better accommodated, and the two tracks for local trains would no longer be necessary. For a two-track subway the cost of construction would of course be greatly reduced.

It may be objected that in New York City the traffic is so dense that the local subway tracks are needed as well as the surface lines; but, as we have pointed out above, New York City conditions are peculiar and may not be safely taken as a guide to conditions in other cities.

The point we wish to bring out is that the traffic on a city street could be provided for at minimum cost and with a maximum of public convenience, by a combination of electric cars on the surface of the street and express trains on a double-track railway placed either on an elevated structure or in a subway, and stopping at intervals of one mile to two miles. By making the express line two-track on the open road and three-track at the stations (as has been suggested for the New York Rapid Transit Ry.) it would have a traffic capacity equal to the needs of almost any city.

But to get the best results and best accommodate the public, such a system ought not to be operated on the flat 5-ct.-fare basis. The fact is that the nickel fare is fair neither to the companies nor to the public. The passenger in the subway, riding 8 to 12 miles for a single 5-ct. fare, does not pay the whole cost to the company of carrying him. On the other hand, the man who wishes to ride a short distance on a surface car has to pay several times what his journey has cost the company.

We are not advocating the adoption in the United States of the system of payment by distance on street-cars which prevails in Europe, but we do believe that our American street-car companies must take a leaf out of European experience if they wish to restore their finances and also restore themselves to public favor. If, instead of the free transfers which were so generally granted a few years ago, 3-ct. fares had been inaugurated instead, both the public and the companies would have gained.

At the present time, the 5-ct. fare loses to the street-car companies millions of passengers who will walk some distance to save their nickels but who would take the street-cars instead if they could do so at a cost of only 3 cts. And these short-distance riders are the very ones that pay the profits. By blindly and stupidly sticking to the 5-ct. fare, the eminent financiers who have so long mismanaged a large proportion of the street railways of the United States have succeeded in diverting from their lines the most profitable class of patrons.

We have described above a street-traffic system consisting of a surface street-railway line with express trains overhead or underground on the same street. Suppose the fare charged on the surface cars was 3 cts. and on the express trains, 6 cts. or 7 cts., whichever was necessary to cause the traffic on the subway to pay a good profit on its cost. Passengers making a journey on both the surface and express trains might be carried at a reduced fare. This could be easily accomplished by selling strips of tickets with those for the surface and express trains alternating. It may seem to some of our readers that this question of the fare to be charged is not an engineering question. Nevertheless upon this question turns the decision whether subways involving an investment of many million dollars shall or shall not be built.

We have not subscribed to the new doctrine now being industriously disseminated by street railway managers, that rates of fare ought to be raised. We do, however, appreciate the economic absurdity of charging 5 cts. to the passenger for the privilege of riding a block in a slow-moving horse car over a group track laid on the street surface and the same sum to the passenger who is carried at express train speed over a journey of 10 to 15 miles on a roadway costing millions of dollars a mile to construct.

LETTERS TO THE EDITOR.

Advice to Engineers to Branch Out.

Sir: I have been very much interested in the discussion in the columns of Engineering News of compensation and professional standing of engineers and would like to say my say about the matter. While it is no doubt true that engineers receive smaller pay then men in some other professions, it seems to me that the cause and the remedy lie with ourselves. In the East (I mean east of Ohio) most young engineers, whether civil, electrical or mechanical, start out as draftsmen, rodmen, linemen, machinists, or assistants, and take a long time to get anywhere. Knowing only one line of work, and often without a broad education outside of engineering proper (if, indeed, there be anything not related to engineering) they lack the self-confidence to tackle a job that requires some other sort of knowledge.

There is engineering work going on, and plenty of it, but the man who is designing steel buildings at $100 a month is afraid to try his hand at reinforced-concrete bridges, and the electrical apprentice in the test department is afraid to apply for a job installing plants.

My suggestion is that the fellows who are not getting ahead as fast as their abilities warrant, should look up some line where they are needed, and widen their education. The private who can and upon occasion does show a better grasp of the situation than the sergeant is the man who will get the next chevrons. We know a lot of things the generals have not had time to learn. A large percentage of young doctors and lawyers have their independent practice, and a much larger percentage of young engineers should have theirs. The idea of sticking to a steady job, though a poor one is wrong. If a man can make good he has no reason to be afraid of competition. If he can't, he has no kick coming, and should stay where he is. Yours truly,

A Western Electro-Civil.

Omaha, Neb., May 24, 1909.

A Defense of the Reinforced-Concrete Truss.

Sir: I wish to make a few brief comments on the criticisms in your editorial of April 22, p. 440, on trestle and truss spans of reinforced concrete.

Being guilty of designing two very important bridges over the Cumberland River in this city, the approaches to which are of the types named, naturally the matter is one of peculiar interest to me.

I agree with you that an engineer is not justified in using a concrete truss, unless such a use can be justified by economy and adaptability to local conditions. I cannot adopt your views, however, that the uncertainty of absolute mathematical calculations of all stresses should deter one from using a construction which experience and tests show to be amply safe. Take for instance one of the oldest forms of construction, the arch. The stresses are not definitely determinable. All calculations are based on certain assumptions, which may or may not be true. Shall we therefore abandon the use of the arch?

In your issue of Nov. 28 1907, p. 589, you published a letter of mine showing several photographs of an iron highway truss bridge, built in 1850, on one of the most used highways in this county. It has seen hard service for 60 years, and still stands in service. It was built (as you point out is the case in all pioneer construction) after the then prevailing type of timber lattice bridge. The same web and flange sections prevailed throughout its length and with no material change in depth. Mathematically it is very faulty, and stressed even to a dangerous limit, yet the constructor, by some means we do not know, evidently got his section heavy enough at the weakest point to stand. This bridge has outlasted dozens of timber bridges in the same locality. Now was not the pioneer engineer justified in putting up an "innovation" although he could not mathematically demonstrate the reason for the "faith that was in him?"

If engineers in time past had never constructed until every feature of a design could be accurately demonstrated would not have progress been exceedingly slow?

On the Starkman St. bridge here (Eng. News, Feb. 25, 1909, p. [illegible]) we have two spans of concrete deck trusses, no doubt the longest spans of heavy concrete construction on this side the Atlantic. The bridge is 60 ft. wide, built for double-track street railways, street traffic and two sidewalks. It was assumed in the calculations that 40-ton motors and 30-ton trailers would some day be used on the railway tracks. The static load, however, is so much in excess of any probable live load that the stresses produced by an unsymmetrical loading cannot be of any serious moment. These stresses were investigated under several assumptions and a model of one-tenth size made and tested by loading uniformly and eccentrically and loadings far beyond any possible live load in actual service applied without any defects showing up. The test was carried out in the presence of three of the most prominent members of the American Society of Civil Engineers, one of whom has been at head of one of the oldest steel bridge companies of the United States for many years, and they, after the test, expressed the utmost confidence in the design.

The question will be asked, however, why not have used a steel truss?

The reasons for not doing so were:

1st. Underneath was the freight (team) yards of the Illinois Central R. R., where constant switching is done. The maintenance of steel over the sulphurous fumes of switch engines is very expensive and difficult even where the most careful attention is given, and as this bridge was to be maintained by the city it was feared it would be neglected and the steel would rapidly deteriorate.

2d. To build a steel truss and encase it in concrete would have been much more expensive, and if a concrete construction which would answer the purpose could be designed and built at less cost why waste the extra money?

3d. Arches could not be used as there was no space available for the piers and abutments.

4th. The construction was not unusually difficult to carry out, and the first cost was only slightly in excess of an unprotected steel truss span with a concrete floor.

You may be assured it was from no desire to build something of a "freaky" nature that prompted us, but we believe an unusual condition was met in the most economical and practical way. It has been my idea that the engineer could not afford to be bound too closely by precedent. If we followed the advice of the prophet of old, "to stand in the way, and seek ye the old paths," our great streams would still be unbridged and creeks crossed by foot logs.

As to the concrete trestle. It is as cheap as a steel viaduct with a concrete floor; it can be made architecturally more pleasing, and is less expensive to maintain; then what can be the objection to using it where the conditions permit? Your views as to this type under heavy and rapid moving loads such as railroad service are well taken, I think. Experiments should be made on simple structures for such loads before long spans and high columns are tried.

At some early day I hope to give your readers a more detailed account of our bridges, one of which we expect to open to the public on July 5 of this year.

H. M. Jones,
Engineer, Cumberland River Bridge Committee.
48 Cole Bldg., Nashville, Tenn., May 21, 1909.

Comment on the Report of the Joint Committee on Concrete and Reinforced Concrete.

Sir: Kindly allow me space to comment upon the "Progress Report of Special Committee on Concrete and Reinforced Concrete,"* published in the "Proceedings" of the American Society of Civil Engineers, Feb., 1909 (Eng. News, Jan. 28, 1909, p. 106, 111.) This report is of such vital importance that it should be made the subject of free discussion, both in the Society and out of it, as it will be made use of and pointed to as authority by engineers of all grades.

There are some things in the Majority Report that are most important and timely. For example: (1) The condemnation of articulated structures in imitation of steel trusses. (2) Mention of the harmful effects of manure on setting concrete. (3) Mention of the superiority of good, wet, dense concrete for waterproofing over the use of dope in inferior dry concrete. (4) Recognition of the fact that concrete in compression will take vastly more shear than concrete in tension or under no longitudinal stress, and that the latter will take very little shear. (5) The condemnation of re-rolled rails.

Articulated or framed structures in concrete are becoming entirely too common; trusses and viaduct bents in this material are bad; manure is recommended by many writers for covering concrete in cold weather; dope is recommended for waterproofing; many tests appear to show that concrete in shear is nearly if not quite as strong as in compression! It is because the common notions about the five points mentioned are diametrically opposed to the statements of the Report that I think it is high time to emphasize them.

In the rest of the Majority Report, I do not find much to commend, and I am in accord with the Minority Report in the statement that it is hastily prepared, not carefully considered, and should be referred back for revision.

The Report appears to be for the benefit of the commercial designer, to give him a chance to compete with other forms of construction and not for an engineer to build a safe and lasting structure. It gives specifications and methods of design that will place reinforced-concrete structures on a par with commercial highway bridges.

For tension in steel 16,000 lbs. per sq. in. is recommended. I know that this is a common unit. All engineers know that it means cracks in the concrete, whereas about 10,000 to 12,000 lbs., with the aid of tension in the concrete, will mean integrity of the structure. What warrant can there be for building structures that the designer knows will crack if they ever receive their load? It is not that tension in the concrete should be calculated, but that there is justification for using units that tests show will leave a whole structure after being loaded with the safe load. A hint is given in the Report of still higher units allowed, else why should specifications for 105,000-lb. steel be given? There is no justification for the use of high steel in concrete.

Another high unit is 16,000 lbs. per sq. in. for buried steel in compression. On p. 107 the Report reads, "The compressive stress in reinforcing steel should not exceed 16,000 lbs. per sq. in. or 15 times the working compressive stress in the concrete." *Designing* designers will use the 16,000 lbs. and fail to see the "15 times the working compressive stress in the concrete." Even the latter has no justification. When tests have repeatedly shown that a concrete compression member in which there are longitudinal rods embedded is capable of taking *less* ultimate load than a concrete member of the same size without the rods, what possible justification can there be for allowing *any* compressive stress on rods in concrete? I pointed out in Engineering News, Dec. 17, 1908, p. 679, that longitudinal rods do not reinforce concrete in compression: even hooped columns, if the hoops are not close, may be weaker than plain concrete. I anticipate that years hence this will be stated in text books or even in committee reports. The sole semblance of defense of this false doctrine of reinforcement by addition of longitudinal rods and occasional hoops that I have seen since my letter appeared is a statement that the 7-in. circle of the hoop should be taken instead of the 9-in. square of the column. Designing designers will take all they can get. They are willing even to count in the ornamental veneer of a concrete column in supporting the load. Rather than lose the value of concrete outside of a hoop, they will put the hoop outside. The Report says that the area within the protective covering is to be considered the column. It says elsewhere that the protective covering may be cinder concrete. It gives a rule for the size of the hoops. They are to be "not less than 1% of the volume of the column disclosed,"* whatever that means. If it is 1% of the volume outside of the cylinder of the hoops, a wire wrapped around the outside of the column would be infinity per cent. of the volume "disclosed," and the designer would be giving far more than he is required; if this wire were ever so thin, he could use 20% higher unit stress on the column, because he has a "hooped" column. What has the volume of concrete disclosed got to do with the requirements for hoops?

It is a pity that this Report did not aim to conserve some life and property by frowning upon concrete columns "reinforced" with longitudinal rods and hooped with hoops that are too far apart to be of any use to prevent the buckling of slender rods compelled to act as columns. Weak columns have been the cause of some very disastrous failures. All beams in a structure may be highly stressed, and yet the failure of one may be only of local consequence: it may merely mean the sagging of that beam. If all the columns of a structure are weak, the failure of one will drag down large portions of the structure: column failures are generally complete and sudden. Many instances of these latter facts have occurred in the last few years, and yet designers go on building columns on the same wrong principles.

The Report has re-clothed some of the threadbare "classical" assumptions. Instead of saying that the concrete and steel are initially unstressed it says: "Perfect adhesion is assumed between concrete and reinforcement. . . . Initial stress in the reinforcement due to contraction or expansion in the concrete may be neglected." *At last!* it is admitted that even these assumptions are not entirely borne out by experimental data: they are given in the interest of simplicity and uniformity. The Report goes merrily on to give a list of more than 30 constants and variables to be assumed and guessed at. In the interest of simplicity (!) I suppose. Why cannot the location of the neutral axis be assumed at once and nearly all of this notation put where it belongs—in oblivion.

The Report says that proper allowance is to be made for vibration and impact. Here again some builders will consult their own interests and make impact zero, at the same time using the highest units given in the Report.

The Report says that 650 lbs. per sq. in. is low for bearing on a concrete surface. Bridge builders have for decades been using 250 lbs. on stones far harder than concrete.

The Report gives a formula on p. 102 for slabs reinforced in two directions. It is called tentative and is otherwise apologized for. This formula has no basis either in theory or test.

The Report says that adequate bond strength throughout the length of a bar is preferable to end anchorage, but does not give any reason or tests to substantiate the statement. Reinforcing bars with end anchorage have been condemned without a hearing. I suggested to a college professor who asked for ideas for investigation that he make some tests on beams reinforced with bars curved up and anchored over the supports. He replied that these would not be reinforced-concrete beams. I do not know why. In Bulletin No. 29 of the University Experiment Station some tests are recorded on beams of this sort. These (with the exception of one where the anchoring washer was loose) all failed either in compression of the concrete or tension of the steel—ideal failures, as such failures give ample warning and are most easily guarded against. In the same Bulletin beams with a wealth of stirrups cracked all up in the neighborhood of the stirrups. The cracks in beams with the anchored rods are confined almost entirely to the middle third, whereas in all other beams the cracks were largely in the outer thirds. A crack near the support of a beam is a constant menace, while one near the middle of span is of little consequence.

A method is given in the Report for designing stirrups, but I must confess I would not know how to use it. I think the majority of designers who use stirrups consider them in shear. The formula on p. 118 would give the shear in a stirrup, if it were a possibility for these so-called shear members to take any shear, since the "stress in a single reinforcing member" is dependent upon the space between bars, and is equal to the longitudinal shear in this space. If the stirrups are, as some claim, vertical tension members as those in the Howe truss, each would take the whole shear. But this Report would take only a portion of the shear in the stirrups and then further split this up among the bars that come in a length equal to the depth of the beam. This must mean that the horizontal reinforcing bars act as a beam to distribute this shear, otherwise the concrete would have to carry the shear from bar to bar. There can be no warrant in assuming a horizontal bar to act as a beam to distribute shear.

The use of stirrups in design is based on illogical deductions. I am unable to find any complete analysis of the way stress can get into and out of a stirrup. In fact, this is not possible without overstressing some part of the beam. Bulletin No. 29, above referred to proves by numerous tests and reiterates many times the fact that stirrups cannot act until failure has begun. Any feature of design that presupposes failure before it can come into use is a bad feature and a violation of sound engineering.

Yours very truly,
Edward Godfrey.

Monongahela Bank Building, Pittsburgh, Pa., May 19, 1909.

Steel Templates for Making Joints in Concrete Sidewalks.

Sir: I have noticed several letters of late in Engineering News, with regard to the laying of concrete pavements. Here, in Louisville, one great trouble that has been found with these walks, is the fact that the finisher, by his carelessness in cutting the joint in the top coat, often misses the sand joint below, and cracks in the pavement result. Even with due care in marking the position of the sand joint on the strips, this is likely to happen, owing to the fact that the joint may be pushed to one side of the place marked, in tamping the concrete, after the sand is placed. To prevent this and to make a clean joint, the use of steel templates is now required.

The template is of the depth of the concrete and top coat. It is set directly to grade and the concrete placed on both sides. After the concrete is placed, and the top coat is on and floated, these templates are pulled and the surface troweled smooth. The joint in the top coat is then cut with a tool that will reach through it to the joint below, leaving a clean joint to the sub-foundation.

*The same report is made by the "Joint Committee on Concrete and Reinforced Concrete," consisting of representatives from the American Society of Civil Engineers, the American Society for Testing Materials and the American Railway Maintenance of Way Association.—Ed.

*In the Report of the Committee on Reinforced Concrete of the National Association of Cement Users, a report obviously formulated from the report of the Joint Committee, this sentence reads "1% of the volume of the column *enclosed*."—Ed. Eng. News.

By this method it has been found that the work can be more rapidly done than where the sand joint is used and made by cutting through the concrete with a knife, as has been heretofore the method.

The city specifications call for 4 ins. of concrete and ½ in. of top coat. The templates are therefore made 4½ ins. deep of $^3/_{16}$-in. steel bars cut to the required length. Near each end of the template, a hole is bored through which a hook may be inserted to facilitate pulling them. The use of these templates has only lately been tried here, but so far has given entire satisfaction.

Very truly yours,
F. Eugene Hayes, Jr.

1508 South First St., Louisville, Ky., May 24, 1909.

Reinforced Concrete for Boiler House Floors.

Sir: In your issue of May 13, 1909, p. 523, is an inquiry relative to the durability of concrete when subjected to the heat of fresh cinders and the necessary cold from quenching with water. I have known several cases of railway clinker pits where cast-iron supports for the track girders encased in concrete had in the course of two or three years most of the concrete protection scaled off, due largely, I think, to the scaling action set up by quenching a pile of hot cinders surrounding the protected pedestal with cold water.

Apparently a scale of about ⅛-in. in thickness loosens up and finally comes off after which another scale of approximately the same dimension gradually forms and comes off. Hard brick floors were used in the instances mentioned with apparently little deterioration.

Yours truly,
W. W. Gaffin,
Division Engineer, Chicago & Northwestern Ry.

North Fond du Lac, Wis., May 24, 1909.

Notes and Queries.

The letter in our last week's issue, p. 582, entitled "Earthwork Calculations for Side-Hill Work," from Mr. Robert S. Beard, was published without an important cut. Since then Mr. Beard has forwarded us some additional information. In our issue of next week we will republish the letter with these corrections and additions.

Information regarding the results of the civil service examination for inspectors of streets and sewers in San Francisco, of which the questions were published in our issue of April 1, 1909, has been received as follows:

67 men reported for the first session, of whom only
60 men reported for the second session, and
53 men reported for the third session.

Of these, 20 passed, receiving marks ranging from 75.05 to 87%. The passing mark was 75%.

THE TURBINES OF THE "NORTH DAKOTA," the 510-ft. battleship now building at the works of the Fore River Shipbuilding Co., Quincy, Mass., are described in "Power and The Engineer" for May 25. This vessel has a full speed requirement of 21 knots and demands an aggregate of 25,000 HP. Two Curtis, horizontal, marine turbines will drive twin screws, taking steam at 265 lbs. gage pressure and 50° superheat with 28 ins. of vacuum. The steam-expansion range is divided into nine stages. To avoid excessive pressure in the turbine shell the nozzles of the first stage are so proportioned as to reduce the initial pressure of 265 lbs. to 60 (gage). The resultant velocity of the steam through this stage is such that four sets of running blades are required with three stationary ones. Three rows of running blades with two stationary ones suffice for each remaining stage. The blades for the first five stages are carried on wheels running in steam-tight compartments. The last four stages are placed on a single drum, the difference in the steam pressure upon the front and back of which is used to balance the thrust of the rotor blades. The area through the various nozzles is increased progressively by increasing the number and cross-section to accommodate the greater volume of the expanded steam. Between the main steam chest and the first wheel are 20 nozzles, 18 of which are controlled by sliding valves individually operated by a hand crank working through bevel gears. No valves are used on the nozzles between stages. For reversing, two wheels are used. These run, when not active, in vacuum at the discharge end to avoid windage friction. Nine rows of blading are used, five upon the first and four upon the second wheel. This is not an efficient arrangement, but is permissible on account of the short and infrequent use of this section.

The wheels are made up of disks of boiler plate which are riveted and screwed to cast-steel spiders and rims. The blades are of extruded brass stock set in channel bars which are afterwards bent to the proper radius for either rotor or casing. The channel fins are slotted crosswise to allow this bending. Where the shaft passes through the casing, carbon stuffing boxes are provided to prevent the outleakage of steam at the head end and the inleakage of air at the vacuum end. At the latter end boiler steam is supplied to the clearance between shaft and packing.

A Review of Track Elevation in Chicago.

The city of Chicago in 1892 adopted the policy of requiring the railways entering the city (which had been built originally on the street level) to elevate their tracks and thus eliminate the dangers of street grade crossings. The policy has been followed persistently, with results satisfactory to the city and the railways. The railways accepted this policy, as tending ultimately to their advantage by eliminating the delays to trains and the continual damage suits due to accidents at grade crossings, as well as the expense of protecting the crossings at grade. Both delays and accidents increase rapidly with the growth of railway and street traffic, and would by this time have constituted very serious problems if the separation of grades had not been undertaken.

The city has enforced the policy without the aid of any special legislation, and under the authority only of the police power granted to the city by its charter. Under this authority it has required the railways to do all the work (including the paving and lighting of subways) at their own expense. The work already done and that remaining to be done under the existing ordinances represents a total expenditure of $72,622,000 by the railways. The total cost to the city, for damages to property and for the expenses of the track elevation department (which latter amount to only $66,084), is estimated at $497,343, or 0.68% of the amount paid by the railways.

A description of the general system of track elevation in Chicago was published in our issues of Jan. 11 and Feb. 22, 1900, and several individual pieces of work have since been illustrated and described in our columns. A report reviewing the progress of the work from its inception in 1892 to the end of 1908 has been prepared by Mr. Morris K. Trumbull, the city's Engineer of Track Elevation, under the direction of Mr. Walter J. Raymer, Commissioner of Track Elevation.

The accompanying map shows the status of the work. The details of the mileage, etc., are summarized in Table I., which is compiled from the statistics given in the report, and the general summary in this table gives an idea of the enormous extent and cost of this work. We give below an abstract of that part of the report which relates to the work in general, an advance copy having been furnished to us for this purpose by the courtesy of Mr. Trumbull:*

*A summary of the track elevation work done by a number of cities was published in our issue of April 1, 1909. Similar particulars, with notes of state laws and city ordinances, were given in the report of the Committee on Roadway presented at the annual meeting of the American Railway Engineering and Maintenance-of-Way Association (Chicago), in March, 1909.

Track elevation in Chicago dates [illegible] May 23, 1892, when the Illinois Central Ry. secured [illegible] in the city council an ordinance for the elevation of [illegible] tracks from 51st St. to 67th St., in order to enable it [illegible] handle the heavy passenger traffic of the Columbian [illegible]bition in 1893. The population at that time was 1,2[illegible]0).

A crying need was felt for relief [illegible] a great number of grade crossings, where the railw[illegible] were annually killing and injuring many people. [illegible] few cases had been disposed of at important stree[illegible]by constructing viaducts over the tracks, to accom[illegible]tate the street travel. The viaduct policy had, ho[illegible]ver, become unpopular. The height at which it wa[illegible]essary to erect the viaducts, above the original gr[illegible]of streets, required the construction of long appro[illegible], not only in the streets provided with viaducts, [illegible] in those that intersected the site of the approache[illegible] well. Then, as necessity arose, nearby streets were [illegible]lected for viaducts. The logical result threatened [illegible] that the zones of city property contiguous to the railw[illegible]s were soon to be enmeshed in a network of approac[illegible]s which would not only offer long and heavy grades to [illegible]reet traffic, but would considerably depreciate the valu[illegible] of the property affected.

Responsive to the public demand, but without profound deliberation as to the feasibility of the program, the city council on Feb. 23, 1893, passed a general ordinance which provided for the elimination of all grade crossings in the city by track elevation. This ordinance was drafted by Alderman John O'Neill (afterwards Superintendent of Track Elevation). It was too comprehensive, and the railways declined to enter into the wholesale scheme of construction expense. The administration thereupon made a survey of those zones in which the street crossing travel was most dense, and decided to treat each zone separately, and where necessary, to further subdivide each into elements of reasonable size.

Proceeding upon this theory, the city council, on July 9, 1894, passed an ordinance for the elevation of the tracks of the Chicago, Rock Island & Pacific Ry. from Archer Ave. to West 69th St., and the tracks of the Lake Shore & Michigan Southern Ry. from Archer Ave. to State St. During the past 17 years the city has passed 42 separate ordinances for work of this kind.

By the provisions of the general ordinance (1892) the city was divided into three districts. [No. 1 is the downtown district, bounded by the river on the north and west and 12th St. on the south. No. 2 is bounded by Fullerton Ave. on the north, Kedzie Ave. on the west as far as 39th St., and then by Halsted St. to 65th St., which is the southern limit. No. 3 includes the remainder of the area within the city limits, except portions annexed since Feb., 1893.—Ed.] All railways in these districts were to have elevated tracks by January, 1895, 1897 and 1899, respectively. Thus the railways were required, by this ordinance, to elevate all their tracks within a period of six years. During the 17 years that have elapsed since its passage, the population of Chicago has been increased 85%, until to-day it numbers 2,200,000. Not much work has been done in District 1. There has, in fact, been little necessity or demand for track elevation within this area. Nearly all the tracks in District 2 have been elevated or elevation has been provided for. District 3 offers much for a healthy growth of track elevation relief for the grade crossing evil.

Of the work for which ordinances have been passed, 74% has been completed. The 148.72 miles of railway already covered by track elevation ordinances, is ap-

TABLE I.—TRACK ELEVATION IN CHICAGO.

Railways.	Completed or under construction, Dec. 31, 1908. Mileage: Railway, miles.	Track, miles.	Subways, No.	Cost.	Ordered but not completed. Mileage: Railway, miles.	Track, miles.	Subways, No.	Cost.	Total work under existing ordinances. Mileage: Railway.	Track.	Subways. Individual.	Total.	Cost.
A., T. & S. F.	3.87	7.21	23	$710,000	....	....	..	.....	3.85	7.21	1	23	$710,000
B. & O.	....	....	...	.....	1.53	5.04	10	$1,500,000	1.53	5.04	0	10	1,500,000
C., B. & Q.	5.21	51.34	36	3,500,000	1.70	3.75	7	650,000	6.91	55.09	22	43	4,150,000
Chi. Junc.	5.08	14.95	43	1,500,000	0.79	3.04	14	210,000	5.87	17.99	30	57	1,710,000
C., M. & St. P.	7.53	62.27	47	4,550,000	....	....	..	.....	7.53	62.27	45	47	4,550,000
C., R. I. & P.	7.70	32.30	49	1,408,000	5.10	20.30	34	1,500,000	12.80	52.60	37	83	2,908,000
Chi. Ter. Trans.	4.93	21.60	41	3,400,000	4.24	12.17	20	1,250,000	9.17	33.77	18	61	4,650,000
C. & Alton.	3.55	14.47	35	900,000	....	....	..	.....	3.55	14.47	17	35	900,000
Chi. & Ill. West.	0.92	1.84	4	2,000,000	....	....	..	.....	0.92	1.84	4	4	2,000,000
C. & N. W.	29.44	201.45	223	13,008,000	1.10	4.40	2	770,000	30.54	205.85	176	225	13,778,000
C. & S. E.	....	....	..	.....	1.39	1.80	10	130,000	1.39	1.80	0	10	130,000
Chi. & West. Ind.	10.47	127.24	84	8,500,000	6.24	58.88	34	4,500,000	16.71	186.12	64	118	13,000,000
Grand Trunk	2.27	5.70	25	732,000	....	....	..	.....	2.27	5.70	0	25	732,000
Ill. Cen.	3.58	28.34	24		....	....	..	.....	3.58	28.34	20	24	
Chi., M. & Nor.	3.85	7.21	23		....	....	..	.....	3.85	7.21	1	23	
So. Chicago	....	....	..	3,000,000	0.53	1.34	4	90,000	0.53	1.34	0	4	3,090,000
St. Charles A. L.	0.73	2.08	11		....	....	..	.....	0.73	2.08	10	11	
Ind. Har. (C.I.&S.)	1.05	2.10	22	200,000	....	....	..	.....	1.05	2.10	0	22	200,000
L. S. & M. S.	10.33	77.70	54	3,400,000	3.00	20.50	16	2,600,000	13.33	98.20	0	70	6,000,000
N. Y., Chi. & St. L.	....	....	..	.....	0.80	1.50	5	850,000	0.80	1.50	0	5	850,000
P., C., C. & St. L.	4.70	18.01	46	2,140,000	3.49	20.14	16	2,200,000	8.19	38.15	10	62	4,340,000
P., Ft. W. & C.	8.25	72.91	62	4,674,000	3.76	8.10	16	2,400,000	12.01	81.01	16	78	7,074,000
Wabash	....	....	..	.....	1.61	5.33	11	350,000	1.61	5.33	0	11	350,000
Total	113.44	748.72	852	$53,622,000	35.28	166.29	190	$19,000,000	148.72	915.01	471	1,051	$72,622,000

SUMMARY.

	Length of work—Railway, miles.	Track, miles.	Subways, No.	Cost to railways.
Completed or under construction	113.44	748.72	559	$53,662,000
Under ordinance but not begun	35.28	166.29	161	19,000,000
Total	148.72	915.01	720	$72,622,000

Note.—There were 720 subways built by railways and 24 by industries. The 1,051 subways noted in the upper part of the table include as separate subways the separate parts of continuous subways built by two or more railways on parallel right-of-way. (See Table II.)

proximately 44% of the total mileage within the city limits. Basing an estimate on this percentage, the ultimate cost of track elevation will approximate $150,000,000. This is assuming (1) that the city limits remain as at present; (2) that the growth of population will require all tracks to be elevated within these limits; (3) that the cost per mile of railway will be 80% of that already provided for, on the theory that there will be fewer tracks per mile of railway.

The 744 subways (averaging seven per mile of railway elevated) are classified in Table II., each subway being taken as a single unit even where two or more roads have elevated their adjacent tracks and have participated in the cost of the joint subway.

TABLE II.—SUBWAYS UNDER TRACK ELEVATION.*

	Built and under construction.	To be built.	Total.
Eliminating street crossings	514	144	658
Eliminating viaducts	10	1	11
Foot passageways	10	6	16
At alleys	13	7	20
Eliminating railway crossings	8	3	11
Private contract	4	..	4
Built by industries (exclusive of bridges carrying industry tracks immediately adjacent to railway bridges	19	5	24
Total	578	166	744

*The total number of subways given in Table II. (744) does not agree with the number in Tables I. and IV. This is explained by the fact that many subways cross two or more perallel and adjacent railways. In Tables I. and IV. each joint subway is counted for each railway participating in its construction (and in some cases the different roads used different types of construction for their portions of the subway). In Table II., however, each subway is considered as a single unit, whether built by one railway or by several railways.—Ed.

The benefits from track elevation are many. First and foremost is the manifest reduction in grade crossing fatalities and injuries. Table III. speaks for itself. This record takes no account of the accidents which occurred on the railway right of way between streets. It is a grade crossing record only. Prior to 1899, 35 miles of railway had been elevated and 135 subways had been constructed. This work, comprising about 30% of what has been completed to date, saved many lives and many accidents.

Material results, however, should not be lost sight of. Consider the time that would be lost annually in case no tracks had been elevated. During the year 1908 there were recorded 643,386,000 rides on the surface street railway lines alone. Most of the railways intersect street car tracks every half mile where the city is built up and where surface traffic is heaviest. It is fair to assume that 150,000,000 of these rides encountered railway tracks or subways. If track elevation had not been accomplished, passengers would have suffered many delays due to crossings being blocked. The street cars themselves would show decreased operating revenue. When the delay to pedestrians, teams, carriages, and automobiles is considered, a conservative estimate of the value of time lost would approximate $1,500,000 per annum.

TABLE III.—ANALYSIS OF DECREASE IN GRADE CROSSING ACCIDENTS AT CHICAGO.

		Deaths from all causes		Grade Crossing Accidents. Fatal			Non-fatal		Total	
Year	Population.	No.	Rate per 1,000.	No.	Rate per 1,000,000.	Percentage of total deaths from all causes.	No.	Rate per 1,000,000.	No.	Rate per 1,000,000.
1899	1,626,333	25,503	15.7	113	69	0.44	169	104	282	173
1900	1,698,575	24,941	14.7	97	57	0.39	105	62	202	119
1902	1,815,445	26,455	14.6	61	34	0.23	122	67	183	101
1904	1,932,315	26,311	13.6	55	29	0.21	172	89	227	118
1906	2,049,185	29.048	14.2	68	33	0.23	65	32	133	65
1908	2,166,055	30,548	14.1	20	9	0.07	27	12	47	21
	Average for 10 years.		14.5	...	37	0.026	...	56	...	93

The reduction in fire losses due to track elevation is difficult to compute. Be it said, however, that the delay to the fire department in reaching conflagrations is enormous when the railway crossing gates are closed for passenger or freight trains. Every moment elapsing between the time a fire starts and the arrival of the fire department at the site is vital, and this is a matter of important consideration when viewing the delay due to a blockade at one or more crossings.

Some additional benefits due to track elevation are here enumerated.

1. New districts are opened for settlement by the improved traffic facilities, thus reducing local congestion in population.
2. Courts have fewer cases due to trespass, "hitching," car thieving, etc.
3. Few streets are now crossed by railway yards; 21 yards have been elevated.
4. Better time is made by trains. Fewer accidents occur for which the public has to suffer and for which the railways have to pay. Railway right of way is more clearly defined. Freight trains do not have to be cut at street intersections.
5. Underground pipes and conduits are more accessible in subways than when lying directly under surface tracks. Breakages of pipes and conduits due to the impact of heavy track loads are eliminated.
6. Improvements such as new station buildings, new team yards, new freight houses, etc., are secured. In fact, within the limits of track elevation, the railways are entirely rebuilt along strictly modern lines.
7. Future electrification of the railways is made easier in that the third rail and return circuits can be more easily disposed of.
8. Nine unsightly viaducts have been removed. An additional viaduct will be removed this year. Only three (away from the river) will remain after this year.
9. Seven railway grade crossings have been separated. One more has been temporarily separated. Three additional cases will be disposed of under existing ordinances, with the probability that two more will be agreed upon by the railways before all the ordinances now in effect have been executed.

When one attempts to compare the physical results of track elevation in Chicago as shown on the different roads, one finds that the character is varied. Each railroad has its own standards and the work of each is peculiar to that company. With this diversity of design in mind the writer has secured data from the different companies and has assembled the information in Table IV.*

A number of subways have been depressed so far below the original level of the streets that the street grade is dangerously close to the sewer tops. That this condition is undesirable is obvious. A number of subways on the West and North sides, having surface cars, were provided with only 12 ft. 6 ins. of headroom in the original ordinances. The large cars provided for in the traction ordinances require 13 ft. 6 ins. headroom. How to secure the additional 12 ins. without further depressing the floors of the subways or without necessitating a further elevation of the tracks has been a problem. The railways had completed their track elevation, under their contract ordinances, and were subject to no further demands. On the South side, fortunately, the Chicago City Ry. looked sufficiently far into the future and demanded 13 ft. 6 ins. from the beginning of track elevation. At subways under construction where sufficient headroom was not provided in the ordinance, the Track Elevation Department has successfully urged the railways to provide the additional amount.

The policy of the present administration is to provide 13 ft. 6 ins. of headroom at all streets where surface lines exist, or are probable, and 12 ft. at all others. A smaller amount of depression of the streets is being allowed the railways. Subways are to be provided at least eight for each mile of elevation.

The diversity of design as to retaining walls and abutments, both for foundation and masonry above foundations, is almost as great as in the superstructures. In the early years of track elevation the use of cut stone and rubble masonry was general, but to-day concrete is used exclusively. During the last five years walls and abutments have been constructed of reinforced concrete by some of the roads. Concrete retaining walls above foundation are constructed with "battered" or "stepped" backs according to preference of the engineers.

An earnest effort is being made to prevent the percolation of water through the walls and abutments. This improves the appearance and lengthens the life of the concrete. Some roads coat the back with asphalt or pitch. Some employ longitudinal drainage either 4 ft. or 5 ft. below the elevated track level or at the original grade of the tracks. Some use "weep" holes through the walls.

The writer will not attempt to go into discussion of the methods pursued by the different companies in elevating their tracks, unit costs, etc. Suffice it to say, that, whereas, in the early years practically all work was done by hand, to-day nearly all classes of heavy work are performed by machinery. By the latter method smaller forces can be employed eliminating delays and

*See note under Table II.

TABLE IV.—TYPES OF CONSTRUCTION FOR RAILWAY BRIDGES OVER SUBWAYS ON TRACK ELEVATION WORK AT CHICAGO.

Railroads.	Rows of columns. Single span.	1 Row.	2 Rows.	3 Rows.	More than 3 rows.	Type of bridges. A.	B.	C.	D.	E.	F.	Type of floor system. A.	B.	C.	D.	E.	F.	Type of decking. No decking.	A.	B.	C.	D.	E.	Type of waterproofing. No waterproofing.	A.	B.	C.	D.	E.	Ballasted. Yes.	No.
A. T. & S. Fe	17	1	2	2	0	17	4	1	0	0	0	18	1	0	0	0	3	3	0	19	0	0	0	3	19	0	0	0	0	19	3
C. B. & Q.	12	1	3	20	0	12	5	0	0	16	3	0	17	0	0	16	3	0	16	0	16	1	3	5	16	1	0	14	0	20	16
C. J.	20	0	10	9	1	19	13	7	0	0	1	8	24	7	0	0	1	1	5	2	0	29	3	8	3	1	1	0	27	37	3
C. M. & St. P.	20	1	16	3	0	6	33	0	0	0	1	0	39	0	0	0	1	0	34	1	4	0	1	0	0	0	0	0	40	5	35
C. R. I. & P.	37	3	8	2	0	39	8	3	0	0	0	3	44	0	0	0	3	0	50	0	0	0	0	50	0	0	0	0	0	0	50
C. T. T.	6	0	3	31	1	5	5	0	30	0	1	5	1	0	30	0	5	0	1	0	0	39	1	0	1	32	7	0	1	40	1
C. & A.	17	3	12	3	0	16	16	1	0	0	2	0	35	0	0	0	0	0	0	35	0	0	0	0	35	0	0	0	0	33	2
C. & N. W.	49	3	53	101	0	35	70	5	82	0	14	3	110½	5	82½	0	5	0	107	0	0	96	3	95	15	39	0	0	57	112	94
C. & W. I.	30	3	10	26	0	30	7	26	0	0	6	0	31	27	0	0	11	2	0½	20	36½	1	9	11	1	0	9½	47	0½	58	11
G. T.	9	1	13	1	0	0	23	0	0	0	1	0	23	0	0	0	1	0	0	0	24	0	1*	0	0	0	0	0	24	24	1*
	1*	..	..	..	..	..	..	..	..	..	1*	..	..	..	..	..	1*	..	..	..	..	..	..	..	..	..	..	..	..	1*		
I. C. (including C. M. & N. and St. Charles Air Line)	22	0	22	11	1	20	26	1	0	8	1	14	29	1	0	8	4	5	9	19	0	0	23	29	19	0	0	0	8	27	29
	20	0	0	1	0	20	1	0	0	0	1*	0	21	0	0	0	1*	0	0	0	21	0	1*	0	0	0	0	0	21	21	1*
I. H.	1*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1*		
L. S. & M. S.	26	1	5	11	0	26	6	11	0	0	0	3	29	11	0	0	0	2	37	0	4	0	0	4	35	4	0	0	0	4	39
P. C. C. & St. L.	27	1	6	9	1	27	7	0	9	0	1	12	16	0	0	0	16	0	19	13	0	10	2	0	0	26	0	13	5	23	21
P. F. W. & C.	12	2	10	35	0	11	2	2	34	0	10	2	18	2	33	0	4	0	0	0	0	59	0	0	15	0	3	41	0	50	0
	324	20	173	265	4	283	226	57	155	24	41	68	438½	53	145½	24	57	13	278½	109	105½	235	45	205	159	103	20½	115	183½	482	304
	2*										2*						2*						2*						2*		2*
Percentage of total units.	41.4	2.5	22.0	33.6	0.5	35.9	28.7	7.2	19.7	3.0	5.5	8.6	55.7	6.7	18.5	3.0	7.5	1.6	35.4	13.8	13.4	29.8	6.0	26.0	20.2	13.1	2.6	14.6	23.5	61.2	38.8
Total units	788					788						788						788						788						788	

*Temporary.

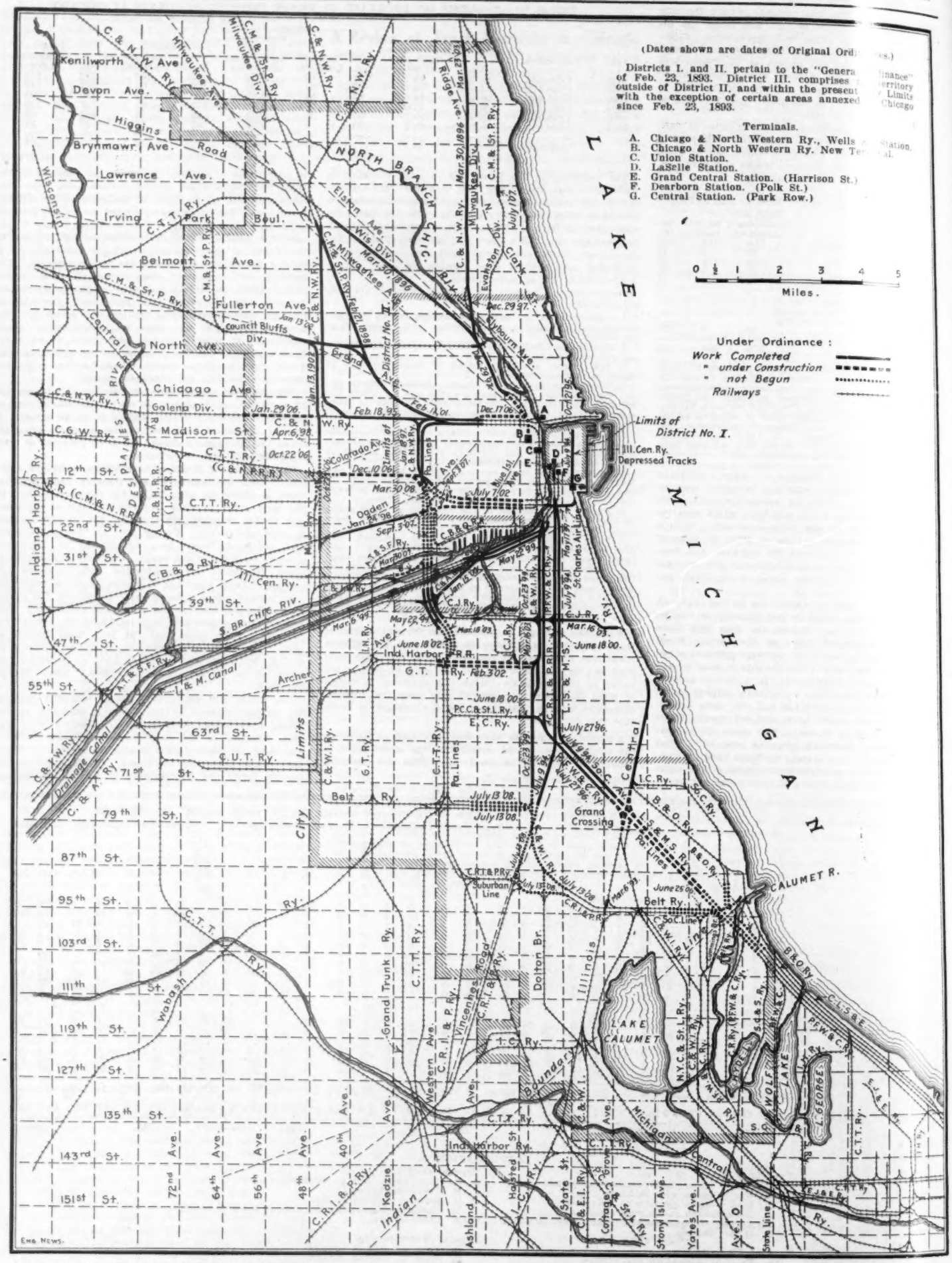
EXPLANATION.

Type of Bridge:
- A. Single girder spans, without columns.
- B. Girder spans with columns.
- C. Deck I-beam spans with columns.
- D. Deck trough spans with columns.
- E. Reinforced-concrete slab spans with columns.
- F. Other designs.

Type of Floor System:
- A. Troughs normal to the girders.
- B. I-beams normal to the girders.
- C. Deck I-beam spans.
- D. Deck trough spans.
- E. Reinforced-concrete slab spans.
- F. Other designs.

Type of Decking:
- A. Steel plate (flat or buckled).
- B. Creosoted timber.
- C. Reinforced-concrete slab.
- D. Concrete surrounding I-beams or filled in troughs.
- E. Other designs.

Type of Waterproofing:
- A. Pitch or asphalt coating.
- B. Pitch or asphalt mastic.
- C. Burlap or felt mopped with pitch or asphalt, but without any protection on top of waterproofing.
- D. Same as C, but with waterproofing protected by creosoted plank, brick, concrete or mastic.
- E. Other designs.



MAP OF THE TRACK ELEVATION SYSTEM OF CHICAGO, SHOWING THE WORK COMPLETED, UNDER CONSTRUCTION, AND REQUIRED UNDER EXISTING ORDINANCES.

uncertainty due to labor troubles. The rate of progress is thereby accelerated and a more uniform daily output assured. Even with the use of machinery, track elevation gives employment to about 5,000 men annually in Chicago.

Taken as a whole, Chicago track elevation as it appears to-day is a most satisfactory public improvement. There are a few places where reconstruction will be necessary in the near future. There are subways which are poorly drained due to the inadequacy of the existing sewers. The latter, however, is a general evil which is not confined to the areas in which railway tracks are located.

With a congested right-of-way to begin with, the railway must rebuild from below the ground, and must handle its traffic without delay at the same time. The Commissioner of Public Works permits the blocking of but three or four consecutive streets at any one time. Two miles of track elevation, for instance, must be divided into from four to five separate sections, in each of which the operations are separate and distinct. The object of this is to offer the minimum of obstruction to street travel; especially to surface cars and the city fire department. This restriction upon the railways increases the cost of the work, complicates the handling of trains, and lengthens the time required to complete the work. Even this program cannot wholly eliminate the damming of the arteries of travel contiguous to the particular section in which the heavy operations are being carried on, nor the temporary suspension of normal business on the part of a few tradesmen who happen to be located immediately adjacent to the section that is being elevated.

The engineer must carefully map out his program for the season and follow this schedule with a daily "line-up" which has in view the logical sequence of each distinct operation. The nature of the work requires that heavy operations and large forces of men must be handled within limited areas. The time interval between each operation must be calculated to a nicety. Upon consideration of the many complications involved one wonders at the dispatch with which the work is accomplished.

Strictly speaking the authority of the Track Elevation Department ceases in any piece of elevation as soon as the plans submitted by the railways as their interpretation of the provisions of the ordinance, are approved. At this stage the authority of the Commissioner of Public Works begins. He issues all permits, passes on the program of the work and inspects all material and workmanship. As a matter of fact, however, the Track Elevation Department cooperates with the Commissioner of Public Works during the progress of construction and not only consults with the latter, when called upon for advice, but follows each piece of track elevation from start to finish.

A Reinforced-Concrete Retaining Wall Along the Bank of the Ohio River.

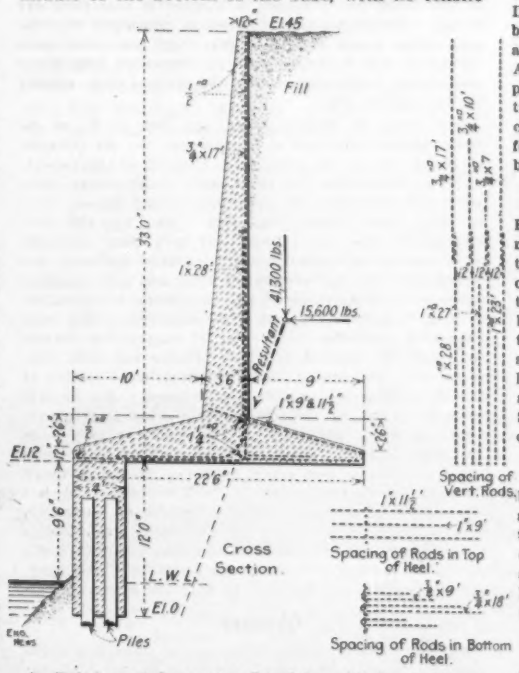
By FRANK A. BONE.*

The Ohio River with its extremes of high and low water levels presents quite a problem to those who wish dock service available at all seasons of the year, with the unloading machinery and storage facilities located above the high water levels.

The Evansville Sand & Gravel Co., of Evansville, Ind., during the past season has made permanent improvements along this line that are somewhat novel, at least in the design of the retaining wall. It was desired to locate a derrick and hoisting machinery above high water level and near enough to the deep water in the river to reach and unload barges at all stages of the river by a derrick hoisting the cargoes and placing them in the yards of the company, in bins or in railway cars above high-water level.

The variation of the river from low to high water at this place is about 44 ft. A retaining wall 45 ft. from foundation to top was decided on, a cross-section of which is shown in the accompanying figure. The two rows of piling shown in the drawing had been in place several years, as had also the fill on the shore side of the piling. The fill was composed mostly of sand and earth mixed with stones 6 to 8 ins. in diameter. The river at this point is generally the most of the year below a 12-ft. stage, so it was desired to have as much of the construction above that level as possible and as little below.

A row of sheet piling made as water tight as possible was driven about 6 ins. outside of the outer row of piling and the earth excavated from around the bearing piles to a depth of about 2½ ft. below low water. From that point upward the piles were encased in a wall of concrete 4 ft. thick. This wall was continued above the tops of the piling to an elevation of 12 ft. above foundation. This was built when the river was low, with the mixer located on a decked barge. This 4-ft. wall, to the height of 12 ft., cost but a fraction of what the ordinary base of a 45-ft. (either gravity or reinforced) wall would have cost. It is, however, adapted at the top portion to carry little except vertical loads from what we may call the superstructure of the wall which it partially supports. The superstructure was therefore made with a very broad base (more than two-thirds of the height) in order to bring the resultant back of the middle of the base, and also to bring at least one-half of the weight of the wall on the heel, thereby causing friction on the well settled fill already in place, and thus preventing the tendency of the superstructure to slide forward. It will be noticed that the resultant for the superstructure and backing will, if extended, strike far back of where the piles enter the earth. The heel and most of the base was on a foundation that was to some degree compressible, so it became necessary to extend the reinforcing transversely entirely across the bottom of the base, for when the wall was first built and before the fill was in place the greatest tensile stress was in the middle of the bottom of the base, with no tensile



A Reinforced-Concrete Retaining Wall at Evansville, Ind.

stress in the upper rods of the heel. After the fill was made the stresses in the heel were reversed, the lower rods being relieved and the upper rods being brought into action by the outward and downward pressure of the fill.

The superstructure, excepting the broad base, was erected after the water for the season had risen to a height that would have prevented work on the structure below a 13-ft stage of the river without the use of an expensive cofferdam.

When the river is improved with locks and dams as is proposed, the low water level at this point will never be below the tops of the piling as shown in the drawing.

The main advantage of this design of wall, aside from the light downward pressure it causes at the toe and the economy of material, is the small proportion of construction that had to be done, either at the extreme low water season of the year or else behind a cofferdam.

A SLIGHT EARTH SHOCK was reported May 26 in Indiana, Illinois, Wisconsin, Michigan and Iowa. The shock lasted but a few seconds and only minor damage was reported.

A WASHOUT caused the wreck of an engine and caboose May 29 on the Mobile, Jackson & Kansas City R. R., near Mobile, Ala. Three trainmen were killed and four others injured.

A BOILER EXPLODED in the Geesey hoop mill at Dowagiac, Mich., May 26, fatally injuring one man and killing five others, of whom one was the owner of the mill. There were eight men in the mill at the time of the explosion. The building was completely wrecked.

A BRIDGE FIRE destroyed part of the High St. bridge at Alameda, Cal., on May 21. The draw-span of the bridge is of steel, but the approaches are timber trestle work. Fire started from unknown causes, and oil and asphalt on the roadway gave it good fuel. The approaches were practically consumed, and some of the wooden paving of the steel span also was burned.

A TORNADO IN TEXAS May 30 wrecked the village of Zephyr, in Brown Co., killing about 30 persons and injuring severely 50 others. The storm cut a swath 300 yds. wide extending through the residence and business section. About 50 buildings were completely demolished by the wind, and a fire which started in a lumber yard consumed an entire block of store buildings.

The towns of Key West and Depew, in Oklahoma, were visited by a tornado May 29. Both towns are reported to have been wiped out. Ten persons were killed at Key West and five at Depew, while about 40 others were injured.

Somewhat less severe wind storms were reported May 29 at Edgerton, Kan., and Jamestown, N. Dak.

THE PANAMA CANAL IS TO BE FORTIFIED, according to statements published shortly after Secretary Dickinson's return from the Isthmus. It is said that batteries will be placed on the islands in Panama Bay adjacent to the Pacific entrance to the canal, and also on Ancon Hill. On the Atlantic side, batteries will be placed upon the promontories commanding the canal entrance. Secondary batteries will also be installed to command the lock sites. The total estimated cost of fortification, according to these published statements, will be $6,000,000 to $7,000,000.

THE TENNESSEE PASS TUNNEL, on the Denver & Rio Grande Ry. near Leadville, Colo., caved in on the morning of May 19. According to published statements, the cave-in occurred about 1,000 ft. from the west portal of the tunnel, and about 500 ft. of the timber lining of the tunnel was crushed in. The cave-in was discovered by a trackwalker in time to prevent accident to any train. Evidence that the timber lining was being strained and was liable to give way was discovered 48 hours before the cave-in occurred, at which time a small amount of debris fell onto the track from the roof. Shortly after this had been removed the cave-in occurred. The tunnel was built some 20 years ago.

SPEED OF RAILWAY TRAINS in Indianapolis is to be regulated by zones, according to an ordinance framed at a joint meeting of railway officials and members of the Indiana Railroad Commission with Mayor Bookwalter, of Indianapolis. The speed limits in the three zones are 12 miles an hour in the first district, 25 miles an hour in the second district, and 40 miles an hour in the remainder of the city.

THE SITE OF PRINCE RUPERT, the Pacific terminal of the Canadian Transcontinental Ry., is to be brought forward as a real estate speculation this summer. A public sale of 2,000 lots in the city was held at Vancouver on May 25 to 29. Subsequent sales are to be conducted in other Canadian cities at a later date. It is expected that the new city will be the port at which this wheat output of the Canadian Northwest will reach tide-water and be forwarded for export.

FOREST FIRES in the Crow's Nest Valley, in Southern Alberta, have devastated over 84% of the total area, according to a report by Mr. H. R. McMillan, Inspector of the Dominion Forest Reserves. Of 212 sq. miles of possible forest area in the valley, 85 sq. miles which have been burned over repeatedly is now a poor, gravelly prairie, unfit for agriculture and of very little value for grazing. The first fire does not usually effect so complete destruction, but a second or third fire rarely fails to kill all the young trees, destroy any remaining seed trees, and burn off the upper layer of soil leaving a barren waste. There are remaining in the valley 33 sq. miles of unburned forest and 60 sq. miles covered with thrifty young growth. The necessity of protecting these tracts from further fire destruction is emphasized by Mr. McMillan.

A McKEEN GASOLINE MOTOR CAR has been put into service on the Northern Pacific Ry. for suburban traffic at Duluth. The car seats 60 passengers and is driven by a 200-HP. six-cylinder, internal-combustion engine.

ACCIDENTS ON THE PENNSYLVANIA RAILROAD are to be reported to the public in full detail, according to a circular issued by the company on May 26. A statement giving all the essential facts will be made public by the company at its general offices in either Philadel-

*Civil Engineer, P. O. Box 85, Cincinnati, Ohio.

phia or Pittsburg, according to whether the wreck is on the lines east or west of Pittsburg. Such statements will also be given out at offices of the division superintendents, and reputable journals can obtain information from such sources. Regarding the causes of accidents, it is pointed out that in many cases the causes cannot be ascertained, even by the railroad company, until after considerable investigation. It is declared, however, that the company will give prompt publicity to all known facts. This departure on the part of the Pennsylvania Railroad Co. is especially commendable.

CAUTION TO STREET RAILWAY PASSENGERS is to be inculcated in Chicago by a series of bulletins which are to be prominently posted in the cars and public places. Caution Bulletin No. 1 reads as follows:

Don't cross tracks without looking both ways for approaching cars.
Don't get caught in the narrow space between two tracks when cars are passing.
Don't fail, when leaving a car, to look up and down the street for an approaching automobile or other vehicle which may run you down.
Don't jump on or off a car while it is in motion.
Don't ride on car steps.
Don't get off facing rear of the car.
Don't cross opposite track after leaving a car without looking for a car or vehicle which may be approaching from another direction.
Don't let your children play near the street car tracks.

DOCKS FOR THE ENGLISH NAVY AT SIMONS BAY, AFRICA.—The importance of the naval docks now nearing completion at Simons Bay, which is situated in the northwest corner of False Bay, South Africa, can hardly be exaggerated when it is realized that, in the event of the Suez Canal being blocked—a contingency which is admittedly of easy and speedy accomplishment—they would form the halfway house to India, Australia, and the East.—London "Times," May 19.

ON STREETS WITH WOOD BLOCK PAVING there is sometimes difficulty with the creosote and tar contained in the blocks working to the surface and making the pavement exceedingly slippery. In Indianapolis recently a wood block pavement gave so much trouble from this cause that it was attempted to remove the surplus tar on the surface by burning it off with the city asphalt repair plant. The experiment was tried, but the volume of smoke and flame proved so great as to injure the shade trees along the street and arouse strong protest from the residents.

Personals.

Mr. S. J. Mulvaney, Trainmaster for the Southern Ry. at Atlanta, Ga., has been appointed Superintendent of the Virginia and Southwestern Ry.

Mr. Loring P. Rixford has been appointed City Architect of San Francisco, Cal., to succeed Newton J. Tharp, whose death in New York City was noted in our issue of May 27.

Mr. W. G. Seibert has been appointed Division Master Mechanic of the Missouri Pacific Ry. at Fort Scott, Kan., to succeed Mr. T. F. Carberry, who has been assigned to other duties.

Mr. Irwin S. Lhoyd, recently an assistant engineer of the Missouri Pacific Ry., has returned to Concord, N. H., and reopened the office of Lhoyd & Mann, civil engineers, at 2½ North Main St.

Mr. Henry A. Young, Assoc. M. Am. Soc. C. E., formerly Chief Engineer for the construction of a new water system for Camaguey, Cuba, has returned to New York City to become Engineer with the Jobson-Hooker Contracting Co.

Mr. H. H. Sinclair, Assoc. Am. Inst. E. E., Vice-President of the Edison Electric Co., Los Angeles, Cal., will take charge June 1 of the Great Western Power Co. in San Francisco, Cal., as Vice-President and General Manager.

Mr. H. B. Fergusson, M. Am. Inst. M. E., and Mr. M. C. Burr, Jun. Am. Soc. C. E., have opened offices under the firm name of Burr & Fergusson, as civil, hydraulic and mining engineers in the Loo Bldg, Hastings and Abbott Sts., Vancouver, B. C.

Mr. T. H. Webb, Assistant Engineer, Wichita Falls & Northwestern Ry., has been appointed Chief Engineer to succeed Mr. R. A. Thompson who has become Engineer of the Interstate Commerce Commission, as noted in this column May 20. Mr. Webb's headquarters will be at Wichita Falls, Tex.

Mr. A. H. Gairns, Division Master Mechanic of the Oregon Short Line R. R., at Pocatello, Idaho, has been appointed Master Mechanic of the Idaho division, only. Mr. H. Carrick, Assistant Division Master Mechanic at Pocatello, has been appointed Master Mechanic of the Montana division, and Mr. George Ross, District Foreman at Salt Lake City, has become Master Mechanic of the Utah division.

Mr. J. M. Braxton, M. Am. Soc. C. E., U. S. Assistant Engineer, in local charge of fortification and river and harbor work at Key West, Fla., has been transferred to headquarters of the district at Jacksonville, Fla., and placed in charge of surveys for barge canal across Florida and survey for inland waterway from Fernandina to Key West, under the direction of Capt. George R. Spalding, Corps of Engrs., U. S. A.

Mr. John F. Stevens, M. Am. Soc. C. E., has resigned his position as Vice-President of the New York, New Haven & Hartford R. R. Mr. Stevens became Vice-President of the railroad company in April, 1907, directly after resigning his position as Chief Engineer of the Panama Canal. During the first twelve months of his vice-presidency he was engaged in making a valuation of the company's property. The official circular announcing his resignation states that he has resigned to accept service elsewhere.

Mr. R. Winthrop Pratt, Chief Engineer of the Ohio State Board of Health, Columbus, Ohio, has been granted leave of absence for a year, during which period he will serve as Director of Sanitary Engineering to the Cuban Government. Mr. Pratt has been granted a year's leave of absence from the Ohio State Board of Health, during which time Mr. Paul Hansen, Assoc. M. Am. Soc. C. E., now Assistant Engineer, will become Acting Chief Engineer for the board. Mr. Pratt graduated from the Massachusetts Institute of Technology in 1898. After a year's service in the Engineering Department of the Boston & Albany R. R., he took up work with the Engineering Department of the Massachusetts State Board of Health. After four years of service in the latter position he became engineer and subsequently chief engineer of the Ohio State Board of Health. During six years' incumbency in the latter position, the Engineering Department of the Board has increased in number of men from one to ten. Besides his official duties in connection with the Ohio State Board of Health, Mr. Pratt has done some consulting and designing work in connection with water and sewage purification outside the state of Ohio, notably at Washington, Pa.

Prof. Earle B. Phelps, Assoc. Am. Soc. C. E., of the Massachusetts Institute of Technology, and Mr. Charles E. North, M. D., for three years Director of the Department of Bacteriology of the Lederle Laboratories, have associated themselves as consulting sanitary experts, with an office at 30 Church St., New York City, and with laboratories near by. They will give their attention to all matters of sanitation and preventive medicine, and especially to the improvement of water and milk supplies, methods of sewage disposal, and the control of epidemics, working in cooperation with other engineers rather than attempting anything in the way of engineering designs and estimates themselves. Prof. Phelps has been connected with the sewage treatment experiment station of the Massachusetts Institute of Technology for several years past, and has been engaged in other lines of engineering work, particularly with reference to sewage treatment, including studies of the disinfection of sewage. Dr. North has given attention to the sanitary production and distribution of milk supplies, and has also given consideration to the control of epidemics, water-supply and other sanitary problems. Prof. Phelps will continue his relations with the Massachusetts Institute of Technology and its sanitary research laboratory, but his business address will be as given above.

Obituary.

William Whelan, Superintendent of the Elizabethtown (N. J.) Water Co., died May 25 at his home in that city. Mr. Whelan was born in Queens Co., Ireland, in 1826 and came to this country when a young man. He had been in the employ of the Elizabethtown Water Co. for more than 50 years.

John J. Horgan, Superintendent of the Cambridge division of the Boston Elevated Ry., died May 28 at his home in Cambridge, Mass. Mr. Horgan was born in Lexington, Mass., and was educated in the public schools of that place. He had been in service of the street railways of Cambridge for 35 years and acted as Division Superintendent since November, 1901.

A. W. Unthank, a civil engineer, died May 27 in Los Angeles, Cal. During the Civil War, Mr. Unthank was engaged in surveying in the vicinity of the Great Lakes and was subsequently employed on the preliminary survey of the Union Pacific R. R. and by the Peruvian Government, on railway construction in the Andes. He later traveled extensively in Alaska and China and made a survey of the Great Wall of China, afterward becoming Professor of Civil Engineering in the Imperial College at Tokio, Japan.

Engineering Societies.

COMING MEETINGS.

AMERICAN WATER-WORKS ASSOCIATION.
June 7-12. Annual convention at Milwaukee, Wis. Secy., John M. Diven, 14 George St., Charleston, S. C.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 16-18. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 21-23. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
June 21-23. Annual meeting at Chicago, Ill. Secy., D. B. Sebastian, C. & E. I. R. R., 327 La Salle Station, Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 23-25. Annual meeting at Detroit, Mich. Secy., P. W. Drew, Wisconsin Central R'y, Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 24-26. Semi-annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 24-26. Annual convention in New York and Brooklyn. Secy., Arthur L. Williston, Pratt Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 28. Annual convention at Frontenac, N. Y. Secy., Ralph W. Pope, 33 West 39th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 29-July 3. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
July 5-9. Annual meeting at Seattle, Wash. Secy., A. H. Dimock, City Hall, Seattle, Wash.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
July 6-9. Annual convention at Bretton Woods, N. H. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 13-15. Annual convention at Toledo, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 15-16. Summer meeting at Indianapolis, Ind. Secy., W. M. Mackay, P. O. Box 1818, New York City.

BROOKLYN ENGINEERS' CLUB.—The building at 117 Remsen St., Brooklyn, N. Y., known formerly as the Nesmith Mansion, has been purchased for a clubhouse. For the past 13 years the Brooklyn Engineers' Club has occupied rooms on the third floor of the Montague St. branch of the Brooklyn Public Library.

The newly acquired clubhouse is a three-story building with brownstone exterior. On the ground floor there is a reception room, 20 ft. × 50 ft., which will be used also for a lecture room at the weekly meetings of the club, and behind this is a dining room in which will be established a restaurant, for members and guests, by the caretaker, who will live in the basement. The library, secretary's office and a smoking room occupy the second floor, and on the third floor are five bedrooms which will be rented to bachelors of the club. The present membership is given as 350.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—The first semi-annual meeting will be held June 24-26 at the Polytechnic Institute, Brooklyn, N. Y. Among the papers to be presented, on June 24, are the following: "Utilization of Low Grade Fuels in the United States," O. K. Zwingenberger; "Creosote Oil from Coal Gas Tar," S. P. Sadtler; "Automatic Acid Egg," Richard K. Meade; "Some Experiments on Case Hardening of Steel with Gases," J. C. Olsen; "Methods of Clay Control," J. G. Dean. Friday, June 25, will be given up to excursions to industrial chemical plants. After visiting the Atlantic White Lead and Linseed Oil Works in Brooklyn, the party will be conveyed on the National Lead Co.'s steamlighter "Atlantic" up the Hudson to Edgewater, N. J., where visits will be paid to the plant of the Corn Products Refining Co. and the Warner Sugar Refinery Co. On June 26 an excursion will be made to the Standard Oil Co.'s refining plant at Bay Way, N. J.

WESTERN SOCIETY OF ENGINEERS.—Two special meetings were held last week at the society's rooms in Chicago. On May 27 there was a "ladies' meeting," at which Mr. Isham Randolph delivered an interesting address on the Panama Canal and his recent visit to the work as a member of the board of engineers. This was illustrated by a large number of lantern slides.

On May 28, there was a joint meeting of this society and the Chicago branch of the American Institute of Electrical Engineering. The subject was the reconstruction of the street railway system of the city, different features of the subject being presented by three members of the Board of Supervising Engineers which represents the city and the street railway companies. Mr. Bion J. Arnold, Chairman of the Board, outlined the general situation, the provisions of the ordinances and the financial arrangements. Mr. Harvey B. Fleming described the system of construction adopted for the car houses. Mr. George Weston reviewed the progress of the reconstruction work and described the system of organization under which this work is carried on.

BROOKLYN POLYTECHNIC INSTITUTE.—An illustrated lecture on the Panama Canal was delivered by Mr. Allen Hazen, M. Am. Soc. C. E., before the Civil Engineering Society, May 24. The lecture was attended, upon special invitation, by many members of the Brooklyn Engineers' Club.

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